POWER

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Keep Up the Pressure!

There is still work to be done and America is not going to shut down because the war is over.

Avoiding Distortion in Turbine Operation

By WEBSTER TALLMADGE
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The turbine must be heated evenly to avoid distortion and probably serious rubbing when starting. Revolve the rotor when warming up the machine. Turbine wheels tend to wrinkle if unevenly heated. Turbines run with very light loads are liable to distortion. Steam or other pipes must not impose strains upon the casing; the sliding surfaces at either end of the turbine must be kept lubricated with oil and graphite.

THE most important thing in preventing any turbine from being damaged lies in keeping it from twisting out of shape. This twisting, or changing shape, called "distortion," may have several different causes. If a steel bar is heated, it lengthens out, and if you lay it on the ground with a support (say a brick) under each end and step on it at the middle, it will bend. If you do not step too hard, it will spring back. Cast iron, bronze or most any material will do the same in different degrees, depending on the material. Some materials expand more than others and some spring more than others.

If a steel bar, say two inches square and a couple of feet long is heated quickly on one side, the part of the metal heated will expand and lengthen out, causing the piece to warp or bend as illustrated in Fig. 1. It will remain distorted as long as one side is warmer than the other.

Consider a large iron cylinder, say three feet in diameter, ten feet long, with walls two inches thick. Heat it up evenly and it lengthens out. Now, instead of heating it evenly, blow a little steam in. The warm steam rises to the top and heats the top wall, causing it to expand; but as the air remaining in the cylinder stays at the bottom, the lower wall will not be warmed, as it is

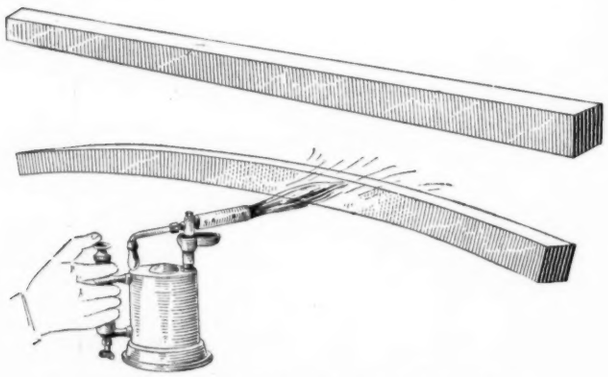


FIG. 1. STEEL BAR DISTORTED BY HEAT

covered with this air blanket. The cylinder will then become distorted as shown in Fig. 2.

In some types of turbines (impulse) the rotating member is in the shape of a wheel mounted on a shaft. Some have a number of wheels, as many as twenty or more on one shaft (see Fig. 3). Sometimes all are about the same diameter, others varying in diameter from small ones at the high-pressure end to large ones at the low-pressure or exhaust end.

These wheels are inside of a casing that is small in diameter at the high-pressure end and large at the exhaust end. When a small amount of steam flows into the casing along the top, it heats only a part of each wheel, causing it to distort, or wave, as shown in

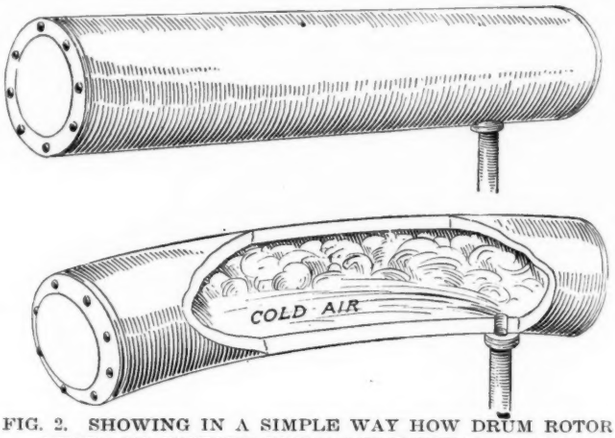


FIG. 2. SHOWING IN A SIMPLE WAY HOW DRUM ROTOR TENDS TO DISTORT WHEN SUBJECTED TO HEAT FROM STEAM

Fig. 4, owing to the local heating and consequent expansion of the metal.

Other types of turbines (reaction) have the rotating member in the form of a hollow drum several inches thick. In some the drums have several different diameters; others have a combination of a wheel and a drum. The local heating of a drum causes distortion similar to that of the cylinder in Fig. 2. Fig. 5 shows such a rotor with the blades attached.

As we are interested in keeping the distortion to a minimum, we must study how to warm the casing and rotor evenly. If the throttle is just "cracked" and the warming done by permitting a small amount of steam to flow into the turbine for a period of say fifteen minutes, or if the turbine is kept warm by a leaky throttle, the steam flows along the top and causes serious distortion of both casing and rotor, and for that reason warming a turbine in this way should be avoided—it creates the very condition you seek to avoid; namely, distortion.

A much better way is to turn on a little steam for a second or two to blow the water out of the drains, having all the drains open. Then give the turbine a good, quick puff of steam (even if the casing is cold) by opening the throttle quickly and sufficiently to start the rotor turning, and as soon as the shaft is seen to start, close the throttle quickly and the rotor will continue to revolve from the impulse it got from the steam. The throttle should then be opened just enough to keep the rotor turning slowly. A good way is to keep it rotating slowly enough to clearly see a spot on the shaft as it turns over. If rotating too fast the spot will begin to look more like a streak, and the throttle should be closed a little to decrease the speed. In warming up in this way, the rotating buckets or blades fan the steam around

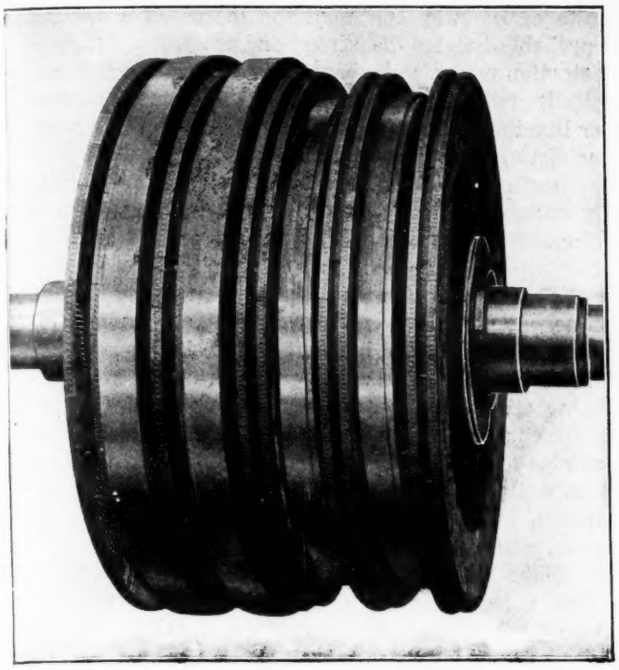


FIG. 3. WHEELS AND DIAPHRAGMS, IMPULSE TURBINE

to all parts of the circumference of the casing and rotor, even though the entering steam has a tendency to flow along the top. If you have been following the practice of warming up a turbine with the rotor standing still, you will notice that it takes less steam to warm up by rotating the rotor slowly; besides it does the job more thoroughly. It will also be observed that if the turbine is very cold it can be rotated slowly for probably ten to fifteen minutes before the exhaust end becomes noticeably warm. The drains should be kept open during the entire warming process. If the unit is started under vacuum, the drains must be piped through a trap into the vacuum space of the condenser, and in any case the drains should each be provided with a check valve as well as a gate or globe valve.

Should there be a severe "rub"—that is, the rotating parts touch the stationary parts—the rotor will stop without doing any damage. Should the parts rub from distortion, the friction due to rubbing will cause additional local heating and consequent additional distortion. If the unit is getting too much steam and running too fast, the rub is likely to become serious. Frequently, a rotor will stop rotating when turning slowly in starting, owing to rubbing caused by distortion. If this happens, leave it a few minutes without touching anything and then try carefully to start it again.

If very cold and a large unit, a turbine should be

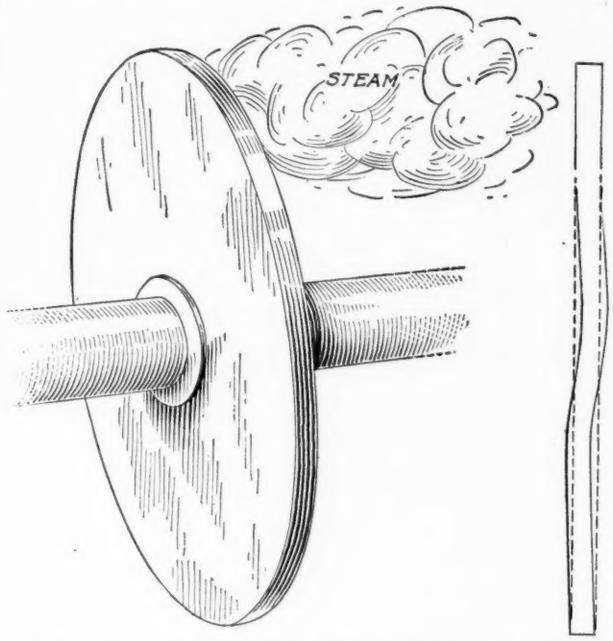


FIG. 4. HOW TURBINE WHEEL DISTORTS FROM HEAT

warmed by rotating it for a half-hour before bringing it up to speed; if small, fifteen minutes will suffice. Frequently, we hear people say, "Start as you please" or "It takes only two minutes to start up." Such practice not only subjects the turbine to the danger of wrecking, but also subjects themselves to an unnecessary hazard. Think, for example, of a wheel already

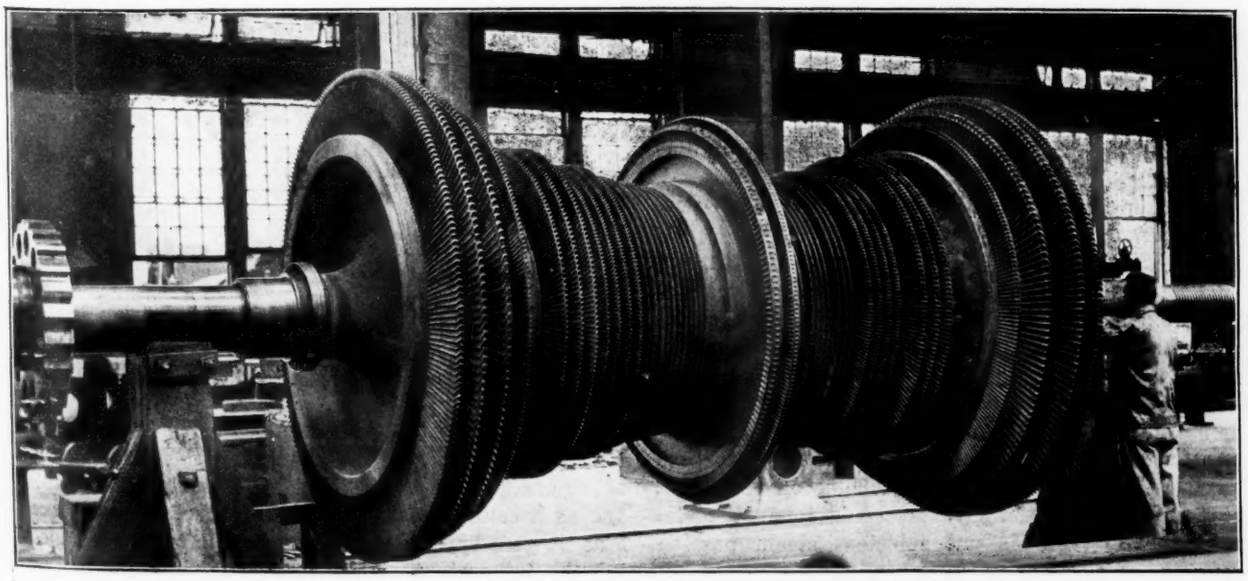
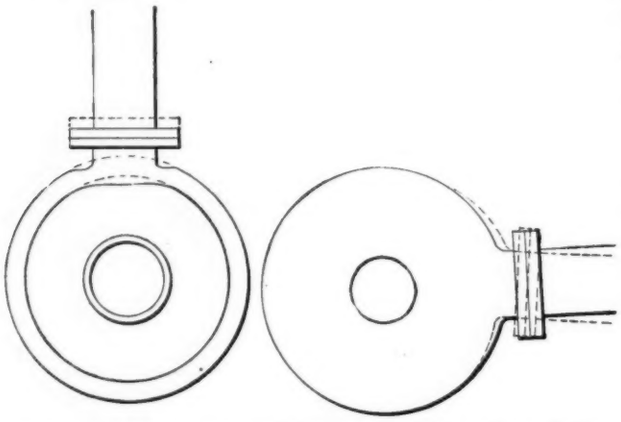


FIG. 5. A DRUM ROTOR. THE BLADES ARE MOUNTED ON A LARGE HOLLOW DRUM

distorted from unequal heating and of the stress in the wheel while distorted; now think of starting quickly to a rim speed of five miles a minute, which is not as fast as many turbine wheels run. At the high speed the centrifugal stress tends to straighten out the wrinkles in the disk or wheel in the same way that a circular saw straightens when coming up to speed. A circular saw usually runs out of true sideways when turning over slowly, but as it comes up to speed there will be a critical speed at which time a noticeable vibration occurs and above that velocity the saw will run true. A turbine wheel does the same, and the stresses caused by the centrifugal force tending to straighten the wheel, opposed by the stress causing the distortion, are enormous. Such a condition is, however, usually accompanied by continued vibration above critical speed in any turbine.



FIGS. 6 AND 7. IMPROPERLY ALIGNED STEAM PIPE CAUSES DISTORTION OF TURBINE CASING

The rapidity with which the parts straighten out depend on the temperature difference and the mass of the parts. The low-pressure parts are usually larger and work at lower pressures and lower temperatures and therefore take longer to become of the same temperature throughout. A good case of this kind is that of a turbine that is started and run on light load for several hours after starting. When starting, the castings are warmed to a temperature uncomfortable to the hand, and the exhaust end will stay hot for hours if the unit is run on light load. This is because there is a small amount of steam flowing through the large exhaust passage and the steam takes a direct path from the low-pressure blading to the condenser without coming in contact with the metal of the castings to cool them off, even if the vacuum in the exhaust is 29 in. (1 lb. abs.) with a steam temperature of 79 deg. F.

It will be seen from the foregoing that a turbine should be started noncondensing or with low vacuum, say 15 in., to get sufficient temperature difference between the steam for warming the turbine and the castings themselves, and that a turbine be put on load as soon as up to speed, and at least one-quarter of full load be put on to get enough steam through to bring the castings to proper temperatures to avoid distortion. It is also advisable not to run a turbine on very light loads, for if the rotating parts should touch the stationary parts, there is not sufficient steam passing through to carry away the heat caused by the rubbing. If the rubbing continues and the steam flow is not sufficient to carry away the heat, the increased distortion will probably become disastrous and cause a wreck.

Distortion may also be caused by external forces mechanically twisting or bending the turbine cylinder, either like the bar of steel mentioned or distorting from a true circle, as in Figs. 6 and 7.

If a turbine cylinder is several feet in length, it is easily understood that when heated it will expand and the increased length must be taken care of without restraining the cylinder. This is usually done by providing a sliding foot under the governor end of the machine, the generator end of the turbine cylinder having been doweled to the bedplate. The sliding surfaces should all be lubricated with graphite mixed with lubricating oil or vaseline. The steam-supply pipe is usually attached to the end of the turbine that slides. The steam pipe must therefore be free to move with the turbine as well as flexible enough to take care of its own expansion. It is also necessary for the flanges to fit properly, and the use of a drift pin to bring the bolt holes in line should not be tolerated. For a good job the pipe must be made to fit either by altering the position by loosening at the joints and taking up the bolt-hole clearances or rebending or recutting the pipe. A flange that comes up like that shown exaggerated in Fig. 7 will effectively distort the turbine cylinder. It is always best to check the fit of the steam pipe with full steam on, up to the throttle and even have the turbine hot. With the pipe in this condition it should be free to move and fit perfectly. Frequently, pipe lines have a drop leg of several feet vertically to the throttle, and invariably a solid hanger will be put on the upper end. When the vertical leg is heated it expands, and as it cannot go downward, being bolted to the turbine, it goes upward, lifting off the hanger and imposing the full weight of the pipe on the turbine casing, not only distorting the casting, but with small units

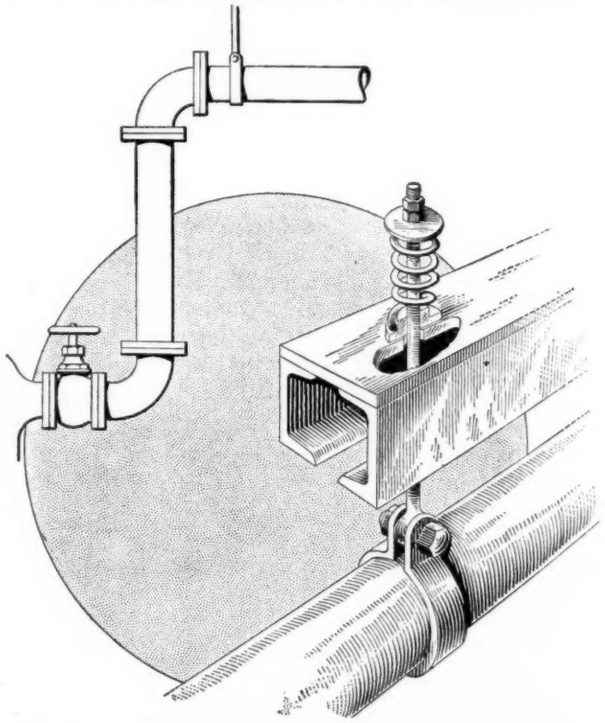


FIG. 8. THE STEAM LINE TO THE TURBINE SHOULD BE SPRING SUPPORTED

pushing them permanently out of alignment. If, on the other hand, the pipe is bolted up hot, it will tend to lift the unit off the base, owing to the contraction of the leg. It is therefore easily understood that a spring is necessary in the hanger to prevent vertical movement of the pipe causing undue strains (see Fig. 8). If the total movement of the upper end of the pipe is ¼ in., the spring in the hanger should be compressed at least 1 in., or four times as much as the expansion. If you find, for example, a spring that compresses ½ in. with the weight of the pipe alone on it and unbolted from the turbine, then use a spring of the same diameter of coil and same diameter of wire twice as long or two springs of these same dimensions in series. The pipe will then be able to move up or down and yet be supported in a large degree by the spring in the hanger instead of being entirely supported by the hanger or entirely by the turbine. This avoids a variable load on both hanger and turbine, which becomes serious when 24-in. pipe ½ in. thick weighing 125 lb. per foot and having cast-steel elbows weighing 2½ tons are used. Such fittings are not unusual at present. With a unit as large as 100,000 kw. in view for the future, more serious consideration must be given this problem.

Distortion may also be caused by strains from excessive movement, especially lateral movement of the exhaust pipe adjacent to the expansion joint or from a turning moment due to changing the center of gravity in surface condensers supported on springs and bolted directly to the turbine exhaust without expansion joints. Surface condensers supported on springs must be provided with rubber expansion joints in the circulating-water pipes, and the atmospheric exhaust pipe, air pipe to air pump and condensate-pump suction from the hotwell must be made flexible.

The turbine foundation must be strong enough to prevent excessive deflection due to the load imposed upon it by the effect of the vacuum tending to lift the condenser, as the movement of a weak or improperly designed foundation would tend to distort the turbine cylinder, especially if the foundation is of structural steel so widely used at present.

The turbine designer has for many years thought out these problems of distortion and has taken steps to provide against destruction from this cause by reducing the area of the surface at points liable to touch so they will readily wear away, thereby generating a minimum amount of heat from friction. He has changed the shape of the parts and carefully anneals the castings to reduce distortion caused by releasing shrinkage strains due to uneven cooling in the molds and by many other processes, but this does not reduce the necessity for one being more careful in the methods of handling the operation of the apparatus intrusted to the operating man's supervision.

Construing Boiler Contracts

By A. L. H. Street

There is an interesting case reported in the decisions of the Maryland Court of Appeals (Vol. 82, p. 397) bearing on the obligations of a manufacturer under a contract for the installation of boilers according to particular specifications.

Plaintiffs installed five horizontal-tubular boilers for defendant street railway company in a temporary plant, according to specifications agreed upon by the parties. On the completion of the work, the defendant company accepted it and entered upon the continued use of the boilers, but withheld part of the contract price on the ground that the heating surface of the boilers was not as great as the contract called for. It was also claimed the boilers would not each develop 200 hp. as called for by the contract, "with the best economy in the consumption of coal." Suit being brought by the plaintiffs to recover the balance due on the contract, the case was disposed of upon the two grounds asserted by defendant, and both points were decided in favor of the manufacturers. The defendant relied upon the folowing clause in the last paragraph of the specifications: "At the water-tube boilers standard factor (11½ sq.ft. per hp.) these [five] boilers will give 1,000 hp. and we guarantee them to stand 135 lb. working pressure."

Affirming the decision of the trial court, the Court of Appeals said:

The defendants contend that the true meaning of this clause is that the plaintiffs were to furnish five boilers of the kind described in the contract, which, when measured by the standard factor of 11½ sq.ft. of heating surface per horsepower, would give a heating surface of 2300 sq.ft. for each boiler. The plaintiffs, however, contend that under a fair construction of the contract in connection with the specifications, they were required only to manufacture and set up in running order five horizontal-tubular boilers of 200 hp. each, and that the amount of heating surface they agreed to furnish for each boiler is clearly shown in the specifications, which are a part of the contract. Testimony of experts was taken to show what is the true meaning of the terms used in the clause in question; but, as might have been expected, the witnesses did not agree. In our opinion, whatever doubts may exist as to the construction of this particular clause standing alone, the meaning and intention of the contracting parties is clear when the specifications, on which the contract is based, are also considered. As one of the witnesses said, "The amount of heating surface in the boilers is in the figures given in the specifications, and it is simply a matter of calculation from these figures." Another witness testified that, notwithstanding the clause we are considering, it is very clear from the specifications that the boilers which the plaintiffs agreed to furnish were not to have the heating surface which is now demanded by the defendant. The construction relied on by the defendant cannot be maintained without putting aside a most important provision of the contract. Manifestly, it would be contrary to all rules of construction to allow one of two or more doubtful constructions of one part of the contract to prevail over and nullify the manifest intention of the parties as declared in another part of the contract. It being conceded that the boilers, as to heating surface, are according to the specifications, the plaintiffs must be held, in this respect, to have complied with their contract.

But in the next place it is insisted by the defendant that the plaintiffs were bound under the contract to furnish boilers that would give 200 hp. with the best economy in the consumption of coal.

We find in the contract itself no warrant for this contention. It is clear from the testimony that the power agreed to be given, namely, 200 hp. for each boiler, was in fact obtained, but without regard to the amount of coal used. It will be observed, however, that the contract contains no stipulation as to the quantity of fuel it would be necessary to consume to get the stipulated power, and we are asked to introduce such a stipulation into the contract merely because we do not find it there, and in order to sustain the defendant's suggestion of an implied warranty. But there is no implied warranty under the facts in this case, for it is well settled "that where a known, described and defined article is ordered, even of a manufacturer, although it is stated to be required by the purchaser for a particular purpose, still, if the thing be actually supplied, there is no implied warranty that it shall answer the particular purpose intended by the buyer; in such case the purchaser takes upon himself the risk of its effecting its purpose." If the question as to economy of fuel had been

in the minds of the parties, or of either of them, it would have doubtless been incorporated in the contract. But they are silent in regard to it, and we are asked to supply the alleged omission. But this we cannot do. In this case we have seen the boilers had the stipulated heating surface and gave the required horsepower, and under the contract given in evidence the defendant cannot set up as a defense the fact, if it be a fact, that the stipulated power cannot be obtained without an undue consumption of fuel.

Godfrey Coal-Handling Conveyor

Small steam plants are handicapped in a measure in handling coal because the initial cost of the necessary conveying apparatus puts a heavy overhead charge on the plant. It would therefore seem that a conveying device that can be installed at a nominal cost could be used to advantage in such plants. To supply the need for such a system John F. Godfrey, of Elkhart, Ind., has designed an unloader and conveyor of the rope-transmission type, Fig. 1. A bucket of 1-ton capacity is used which is dropped into a pit at the railroad siding and is filled from a chute that receives coal from the hopper bottom of the car. The bucket is hauled up an inclined track, Fig. 2, being supplied with trunnion rollers at each side, and is lowered upon the top of the pile or bin. A trigger, Fig 3, releases the bottom of the bucket and the weight of the coal causes it to empty (Fig. 4), after which the spring bottom closes and the bucket is ready for another load. In order to get the bucket back to the starting point a double-drum arrangement and a double pulley on the carrier are used.

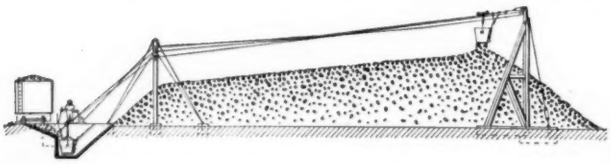


FIG. 1. ROPE TRANSMISSION-TYPE COAL CONVEYOR

The illustrations show the general arrangement of the system when used for storing coal. Either a motor or a gasoline engine is used to operate the system, which can be handled by one man except in cases where it is necessary to clean out the corners of cars or where the coal is frozen. The bucket is automatically dumped and closed, and to dump the load all that is necessary to do is to lower it so that the bucket will come in contact with the coal pile or bunker coal. This opens the latch, and when the bucket is raised again the coal drops on the pile. This operation is controlled by the hoist operator.

As is readily seen, the system can be applied to any kind of work where a space 4 ft. square can be provided for the bucket. When used for filling the coal bunkers in a power plant, the system is operated in practically the same way as when stowing coal in the yard. Naturally, it is limited as to capacity and is not suitable for plants using large amounts of coal.

A Lump of Coal

In attempting to have a recent caller visualize the relation of a lump of coal to the winning of the war, Mercer P. Moseley, Chief of Fuel Conservation for the State of New York, said, "Suppose we allow this small lump of coal on my desk to do a little talking for itself. It says:"

I am a lump of coal. In your eyes I seem a black thing dug from the bowels of the earth. But I am something more. I am a child of the sun that shone hot through humid air for a million years that formed the period of my gestation. Age after age lush and beautiful vegetation covered the earth and was preserved in my form for the use of men who had not been born.

In me was stored up the heat, light and power of the orb of day. I give them forth as I am consumed in fiery furnaces. I drive steamships over every lake and sea, and engines over steel rails across every continent. I fill the world with light. I send through space the wireless messages at which men marvel. Under my hot caress the rocks that were born before me yield up their metallic contents.

I changed the history of the world and lifted the burden of grinding toil from the backs of men when I endowed water with power by converting it into steam to turn the wheels of industry. Since man found wit to use me in this way less than two centuries ago, he has made greater progress in industrial arts and in his standard of living than he had accomplished in all the ages that went before.

Today I am deciding the fate of civilization on the battlefields of Europe. Had I failed the cause of Freedom and Democracy, the Huns would have enslaved you. To me and to the sun that brought me into being you owe your liberties and civilization. Long years ago men worshiped the sun. They should give thanks to the lump of coal he created so that the power of his rays might be stored up for the use of men.

And so I am here to do the work you give me to do. Just in proportion as you conserve and wisely use the power that is mine, so will you perform a service of patriotic purpose or willful waste.

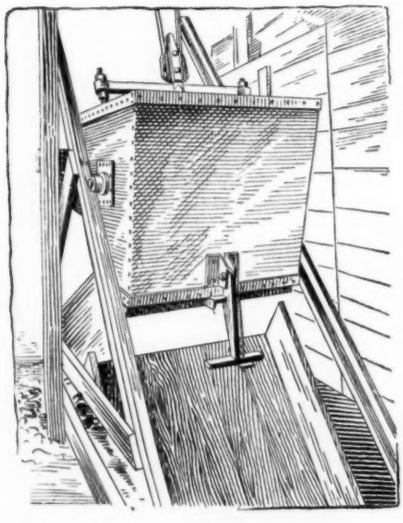


FIG. 2. THE INCLINE

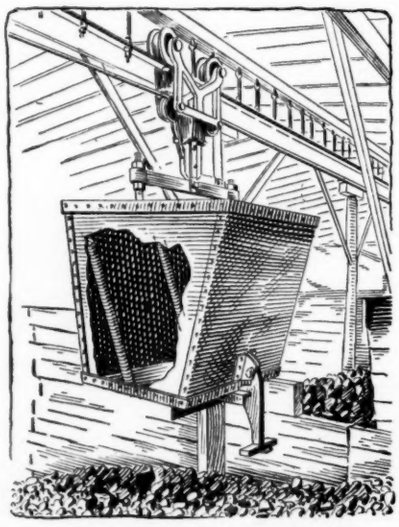


FIG. 3. BUCKET LATCHED

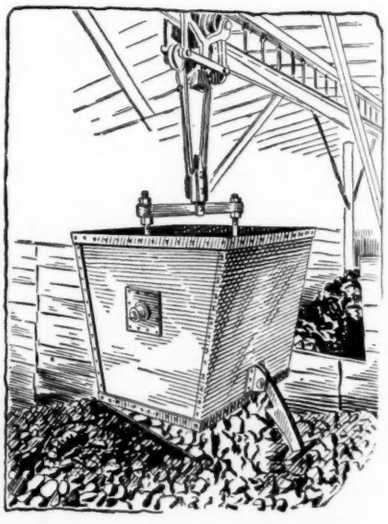


FIG. 4. BUCKET UNLATCHED

The Electrical Study Course—Faults in Generators and Motors—III

Concludes the discussion of open-circuits in the field coils of motors and generators and goes on to a consideration of short-circuits in them, after which a third source of trouble in armature and field windings is taken up; namely, that of grounds.

HAVING observed symptoms indicating an open-circuit in the field coils of a motor such as those described in the previous lesson, it is a simple matter to find in which coil the trouble exists. Assume that it is required to make such a determination in the case of the four-pole machine illustrated in Fig. 1, in which the armature is omitted for the sake of convenience. Remove the lead *a* from its terminal *b* on the starting box and after closing switch *S* bring the handle of the starting box to the "running" position. No current can flow through the armature owing to the removal of lead *a* from terminal *b*, but the line voltage will exist across the terminals *fg* of the field coils. Connect a voltmeter of the range required by the supply voltage first to *f* and *c*, then *c* and *d*, *d* and *e*, and finally to *e* and *g*, or until the coil in which the open-circuit happens to be is found. No voltage will be found across the good coils, but the one containing the break will show a voltage equal to that of the line, in the same manner that the entire voltage across the armature was found to exist across a coil in which a break occurred. If the connections between the coils at *c*, *d* and *e* are insulated, it will of course be necessary to remove the insulation to make the test.

If the motor is a series one, it is not necessary to open the armature circuit as in the case of the shunt type, since an open circuit in the field circuit introduces

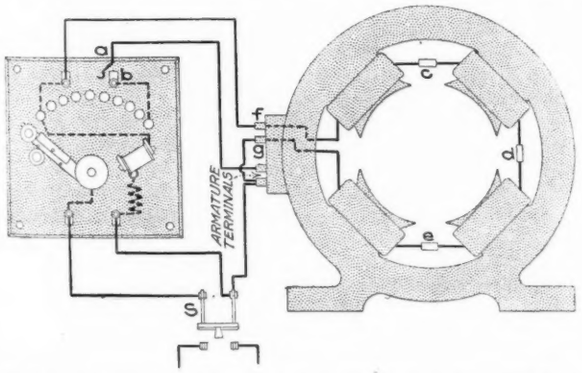
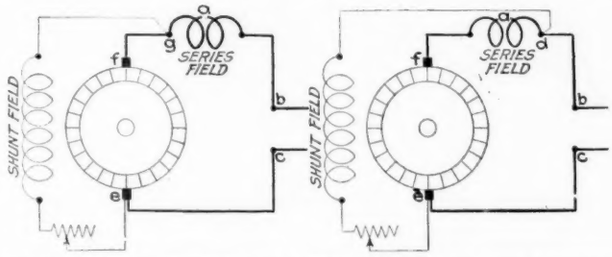


FIG. 1. TESTING THE FIELD COILS OF A SHUNT GENERATOR FOR AN OPEN CIRCUIT IN ONE OF THE WINDINGS

one into the armature circuit. It is, however, advisable to insert a resistance, such as a lamp, for example, into the circuit to forestall trouble in case the circuit should be restored while the starting-box resistance is all cut out, as might happen if the break were due to a loose connection that could be remade accidentally or otherwise. The test would be conducted in the same manner as for the shunt motor, the open-circuited coil being found in precisely the same way.

In a compound machine the manner of test would depend upon whether the open-circuit was in the shunt- or series-field winding and also upon whether or not the latter was provided with a shunt for adjusting the degree of compounding. If the fault is in the shunt-field winding the test is conducted as for a shunt motor; if in the series-field winding, it is conducted as for a series machine excepting that the series-field shunt



FIGS. 2 AND 3. EFFECT OF OPEN-CIRCUIT IN THE SERIES-FIELD WINDING OF A COMPOUND GENERATOR

must be opened in the event that the motor is provided with one. In the case of a compound machine it will be found there are two connections between the coils at points *c*, *d* and *e* instead of one as in Fig. 1, one for the shunt-field winding, the other for that of the series field. They are readily distinguished since the series-field winding is of much heavier wire than the shunt-field; in fact in machines of larger size copper strip is used in place of wire. Breaks in the windings of interpoles are to be treated in the same manner as those in the series windings of the plain type of machine.

The faulty coil having been found, it remains to find the break in it. This cannot be done without removing the coil from its core, and even then it can be found only by unwinding the coil until the break is discovered. Often, however, it is in one of the outer or innermost turns or at the point where the lead enters the coil. In such a case the repair can be made very expeditiously. Unless the break does prove to be in one of the surface layers, it may be more economical to substitute a new coil for the faulty one than to attempt to effect repairs upon it. When putting a coil back into position or replacing it with a new one, care should be exercised to restore the connections in their original order to insure the same direction of current through the coil as that which formerly existed. If the current were to flow in the opposite direction, the polarity of the pole would be reversed and the magnetic flux therefore would oppose that of the adjacent poles.

When a short-circuit is present in a field coil of a shunt machine, it causes an excessive rise in temperature due to the fact that the resistance is reduced thereby, allowing a current larger than normal to flow. The total magnetization may not be affected to any extent since the magnetizing force is proportional to the ampere-turns of the winding; that is, to the number of amperes flowing multiplied by the number of turns through which it flows. When some of the turns are

short-circuited, there are fewer remaining for the current to flow through, but the current which does flow will be greater owing to the lesser resistance of the fewer turns, so that the ampere-turns will remain practically the same. In the case of a multipolar machine this will cause an unbalancing of the magnetization of the machine even though the total flux be unaltered, and give rise to serious sparking.

When a short-circuit occurs in the field winding of a series motor, no undue heating of the coils will be noted provided the full load current is not exceeded, but owing to the smaller number of turns left in the circuit the ampere-turns for any given current will be less, consequently the magnetization will be less and it will require a greater current to drive a given load than it would ordinarily. The compound motor might have a short-circuit in either its shunt- or series-field winding. If it were in the former the effect would be much the same as in a shunt motor, but if in the latter there would be but little indication of its existence.

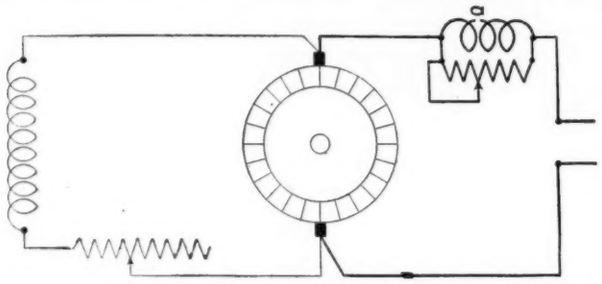


FIG. 4. EFFECT OF OPEN-CIRCUIT IN SERIES FIELD OF COMPOUND GENERATOR WHEN OPERATED WITH SHUNT

As already stated, an excessive temperature rise will be noted when a considerable part of a field winding of a shunt motor has become short-circuited. This will be true of all the coils forming part of the circuit, and indeed the sound coils will become hotter than the defective one since there are less turns in the latter. In the extreme case of an entire coil being short-circuited there would be no heat whatever generated within it since there would be no current at all flowing through. The coil in which the trouble exists would therefore be the one of lowest temperature. In the series motor the temperature of the field coils may not become excessive, but the one in which the short-circuit exists will be cooler in this case also. If the temperature test is not decisive, the faulty coil can be found by taking readings of the voltage across the different coils while current flows through them. Shunt-field coils will require a high-reading voltage-meter and series-field coils a low-reading one. The coil in which the short-circuit is will obviously be of less resistance than the others, and consequently the voltage drop across it will be less. The difference in the voltages will depend upon the number of turns short-circuited; the greater the number the less will be the resistance remaining and hence the lower the voltage across the coil.

Generators exhibit symptoms of a character differing from the foregoing in the following respects. If a break occurs in the field circuit of a shunt generator, there will be no excitation and the voltage will consequently fall to zero. If the machine be a compound-wound one, a break in the shunt field will have the same effect. A break in its series-field winding will cause the machine to refuse to deliver current since there is an open-circuit in it; normal voltage will be generated by the armature if the machine is connected short shunt, but none can be if it is connected long shunt.

This will be apparent from an inspection of Figs. 2 and 3, the former of which represents the short-shunt and the latter the long-shunt connection. There is an open-circuit in the series-field winding at *a*, so that no current could flow through the load from the terminals *bc;* neither could any flow through the shunt field if it were connected as in Fig. 3, since it is connected across *de*, which is equivalent to being across *bc*. In Fig. 2 it is connected across *eg*, which is equivalent to being across the brushes *ef*, and hence we have the connections of a self-excited shunt generator and consequently will find the normal no-load voltage to be present although no current can be delivered to the load on account of the break at *a*. If, however, the generator is equipped with a shunt around the series field for adjustment of compounding, there will be a path for the current as an inspection of Fig. 4 will show.

Short-circuits in the field coils of generators will give rise to practically the same effects as noted in the case of motors, and the tests for short-circuits and open-circuits in them are conducted in the same manner. The cures for short-circuits are similar to those for open-circuits. The affected coil must be removed and enough of its wire unwound to uncover the fault. Fresh insulation must be applied and the coil rewound. As in the case of an open-circuit, it may prove more economical to use a new coil than to repair the old one.

We now come to the consideration of another source of trouble in motors and generators caused by grounds in their armatures or fields. In speaking of grounds it is necessary to distinguish between them and insulation resistance. By a ground is meant a more or less perfect contact between a conductor and some metallic part of the structure upon which it is situated and which normally is not connected to any part of the electric circuit; it is usually confined to a small section of the conductor, the insulation of which has broken down from mechanical wear or deterioration occasioned by excessive temperature or other causes. In contradistinction to this we have the resistance of the insulation which is distributed over the entire area of contact between the conductor and the structure upon which it is mounted. The insulation resistance of all electrical

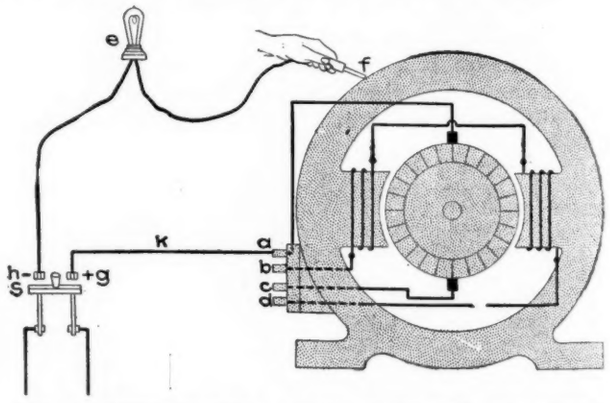


FIG. 5. TESTING FOR A GROUND IN THE ARMATURE CIRCUIT OF A MOTOR OR GENERATOR

apparatus is very great, or should be so, but the larger the appliance the less will be its insulation resistance for the same grade of insulation. This follows from the fact that the resistance of any substance varies inversely as its area. For instance, a conductor whose area is 1 sq.mm. will have 100 times the resistance of one whose area is 100 sq.mm. So in the case of the resistance of insulation, the resistance of 1 sq.in. of the material may be many million ohms, but if a large number of square inches are contained in the area of contact between the current-carrying conductors and the supports from which they are supposed to be insulated, then the total resistance of the insulation will be low as compared with that of 1 sq.in., and will likewise be much less than that of a small piece of apparatus insulated in like manner. New machines in good condition will always have high insulation resistance, but older machines often show up poorly in this respect. Even in the case of very poor insulation, however, the resistance is sufficiently high to prevent any material damage to the machine, but uncomfortable shocks may result therefrom. A ground, on the other hand, is of low resistance and concentrates this resistance at a single point.

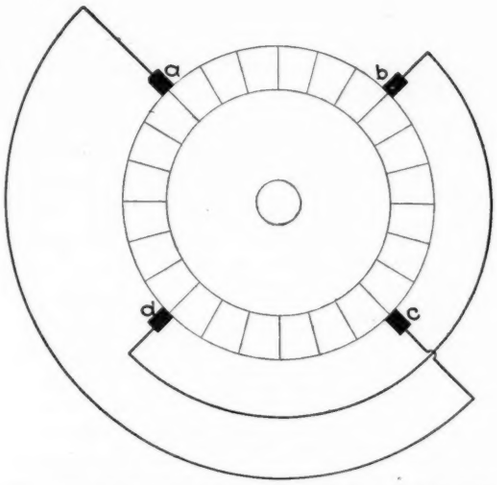


FIG. 6. SHOWING HOW BRUSHES OF A FOUR-POLE MACHINE DIVIDE COMMUTATOR INTO FOUR SECTIONS

Single Ground Does Not Cause Any Disturbance

A single ground in a motor or generator will not make itself apparent in the operation of the machine. An exception to this is when either one of the terminals of the machine is intentionally connected to ground, as is sometimes done; in reality there would then be two grounds and such a case could be considered under the general one of that kind. Although a single ground does not cause any disturbance in the operation of the machine, it should be corrected to avoid trouble. Neglect may result in unexpected shocks to attendants and in disturbance of service or damage to equipment in the event that another ground should develop elsewhere.

When a ground is of little resistance, its existence can readily be proved by a simple test with an incandescent lamp. This method is illustrated in Fig. 5, which represents a two-pole shunt motor or generator. The armature connects to terminals a and c, the field coils to b and d. To test for a ground in the armature circuit, one terminal of the supply switch is connected to one of the armature terminals, in this case a, while the other is connected through a lamp e to the frame of the machine as at f. The current will pass from the positive terminal g of the switch to armature terminal a, through the armature winding to the point at which it makes contact with the core, thence to the shaft and through it and the bearings to the frame, continuing to point f, and from there through lamp e to the negative terminal h of the switch. The lamp should be of the correct voltage for the circuit on which it is used; two or more must be connected in series for the purpose if only 115-volt ones are available when testing on 230-volt or 500-volt circuits. If a "dead" ground exists the lamp will burn brightly, but if the ground has resistance the current through the lamp will be less than normal and it will burn less brightly. The greater the resistance of the ground the more dimly will the lamp burn, and if the resistance has a considerable value the lamp will not even glow. It is therefore seen that the lighting of the lamp is evidence of the presence of a ground, but that its failure to do so is no indication of the absence of one.

The same conditions obtain in the case of a ground in the field windings, excepting that the lamp may never light up to its full candlepower since the field winding has a high resistance and a considerable part of it may be in the lamp circuit. To make the test for the field circuit, the lead k of Fig. 5 is removed from terminal a and connected to one of the field terminals b or d, the remainder of the procedure being the same as for the armature test.

Using Voltmeter to Test for a Ground

When the lamp test gives negative results, it becomes necessary to use a voltmeter, which is then connected into the circuit of Fig. 5 in place of the lamp e, and should be of a range of voltage at least equal to that of the supply line. If the deflection proves to be a large one, it indicates a ground of low resistance, and conversely, if the deflection is small, the resistance of the ground is high. In fact, a small deflection is quite sure to be an indication of low insulation resistance rather than of high ground resistance. When the resistance of the voltmeter is known, the value of the ground or insulation resistance can readily be computed from it and the reading of the voltmeter from the expression $R = \left(\frac{E}{E_1} - 1\right)R_1$, in which R is the resistance whose value is to be found, E is the line voltage, E_1 the voltage read on the voltmeter when the test is made and R_1 the resistance of the voltmeter.

Assume, for example, that a 300-volt voltmeter has a resistance of 20,000 ohms and that if connected in place of the lamp e in Fig. 5, it reads 2 volts when the voltage of switch S is 240 volts. Then we have $R = \left(\frac{240}{2} - 1\right) \times 20{,}000 = 2{,}380{,}000$ ohms, or 2.38 megohms. A ground of such resistance would not be a serious matter. If, on the other hand, the voltmeter reading were 80 volts instead of 2, the resistance would be $R = \left(\frac{240}{80} - 1\right) \times 20{,}000 = 40{,}000$ ohms, a value indicating a serious deterioration of insulation.

Having determined the existence of a ground, the next step is to determine its location and then to remedy it. Means for accomplishing these ends will be discussed in the next lesson.

The last problem concerned a 4-pole 500-volt motor having an armature resistance of 1.4 ohms, whose commutator contained 200 segments, two of which were short-circuited. Assuming that 16 amperes are caused to flow through the armature while it is at rest, it is required to compute the drop in voltage that should exist between adjoining segments all the way around the commutator. Since the armature resistance is 1.4 ohms and the current through it 16 amperes, the voltage drop across it would be obtained by multiplying this value of current by the resistance or, if E is the voltage drop, we would have $E = 16 \times 1.4 = 22.4$ volts. This would exist between each two brushes, as between a and b, b and c, etc., of Fig. 6. Since there are 200 commutator segments in all, there will be one-fourth this number—that is, 50—between each two brushes; consequently the voltage drop between each two will be

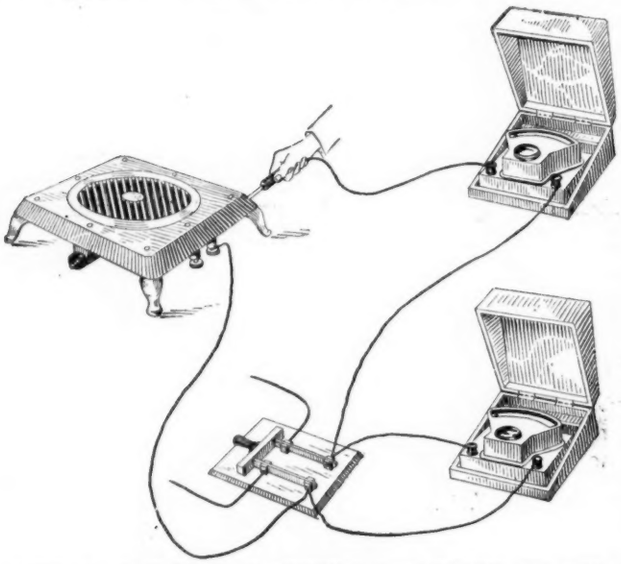


FIG. 7. PROBLEM IN FINDING THE VALUE OF THE INSULATION RESISTANCE OF AN ELECTRIC HEATER

the entire drop across the 50 divided by that number, or $\frac{22.4}{50} = 0.448$ volt. This will hold true for all the segments excepting those in that section of the commutator which includes the short-circuit. There will be only 49 effective coils in this section, and consequently the voltage between segments would be $\frac{22.4}{49} = 0.457$ volt, excepting between those across which the short-circuit exists; the voltmeter reading of which would of course be zero. We therefore have that three sections of the commutator would give us segment-to-segment deflections of 0.448 volt and the fourth one slightly more than this, namely 0.457 volt, with the exception of two segments across which there would be zero volts.

An electric heater, when tested for ground as shown in Fig. 7, gives the following results: Voltmeter A reads 6 volts and voltmeter B 114 volts. If the resistance of voltmeter A is 11,372 ohms, what is the insulation resistance of the heater?

Various Types of Pipe Hangers

The common U-bolt, as shown in Fig. 1, forms about the simplest and cheapest pipe hanger when there exists a suitable structure overhead for attaching it. The rod should be threaded for a considerable distance on each end for adjustment, and for pipes subject to vibration, such as steam, exhaust, hydraulic-pressure lines, etc., there should be jam nuts or other form of nut locks. Where the distance to the joint of support is excessive, or the overhead structure favors attachment at a single joint, the pipe hanger in Fig. 2 is suitable. If a flat bar is used for the crossbeam, it should be bent as shown in dotted lines.

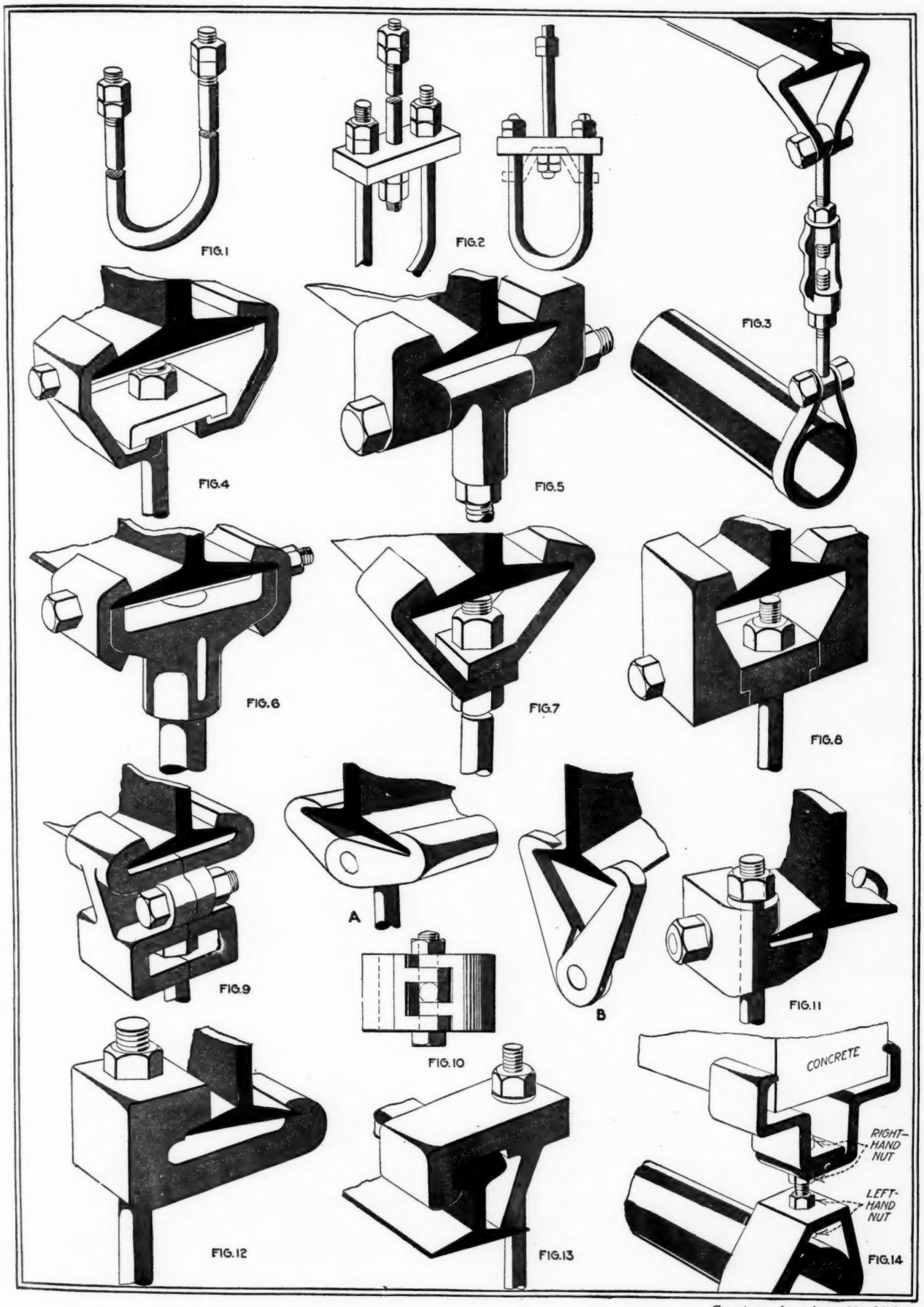
Fig. 3 illustrates a complete hanger with clamp suitable for attachment to the lower flange of an I-beam. The strap in which the pipe rests is made from a broad flat bar of wrought iron or steel, varying in thickness from $\frac{1}{8}$ in., or even less for very small pipes, to $\frac{3}{8}$ or $\frac{7}{8}$ in. for large pipes. A turnbuckle with locknuts provides a means for adjusting the length. The rod ends in the turnbuckle are upset to give the same strength at the rest of the thread as in the full section of the rod, and the whole forms a strong, sightly hanger suitable for nearly any location where minimum cost is not considered a matter of first importance.

A large percentage of the pipes in use at the present time are suspended from overhead beams, and Figs. 4 to 12 show a variety of clamps intended for this purpose. These are mostly designed to be made of steel castings or forgings. On lines subject to shocks, it is useless to attempt the determination of hanger dimensions by calculations of the dead weight to be carried. Only good judgment qualified by experience is of any use in this case, and about the only rule to be followed is the one that says, "When in doubt, make it stronger."

Fig. 10 is commonly made as shown at A. There is less stress upon both the pin and the clamps if made as shown at B. Fig. 13 represents a hanger on T-rails used for supporting heavy pipes in a tunnel with smaller pipes hung beneath them. In Fig. 14 a pipe is supported with an adjustable hanger by grooves formed in a concrete beam. The strength of the groove was found by experiment to be far in excess of that of the clamps, which were designed of ample proportions for the service required.

Large vertical pipes are usually supported from the bottom by means of a properly constructed special fitting provided with a base for resting upon a suitable foundation, preferably of masonry. Smaller ones may be suspended from above by rods connecting to a split collar placed beneath a convenient pair of flanges. Sometimes a vertical line is supported about midway of its length by a fitting made of a bracket form and bolted to the wall.

If you can't do better, get the percentage of ash in the coal, approximately, by putting a carefully weighed sample into any sort of a container that will stand the heat and that is covered close enough not to spill the ash or admit material from the outside, placing this "crucible" in the furnace and leaving it there until all the combustible part of the coal is burned.



Courtesy *American Machinist*

FIGS. 1 TO 14. ILLUSTRATING VARIOUS TYPES OF INTERIOR PIPE HANGERS

Safe Working Pressure for Steam Boilers

By H. F. GAUSS

A simple treatment dealing with efficiency of riveted joints, bursting and safe working pressures for boilers and the permissible pressure on stayed surfaces.

WHEN a boiler explodes, the post mortem usually indicates that a weakness had developed in some detail of construction, due to an improperly designed part or the wrong application of some standard form of construction to the particular case. Given a certain boiler to investigate and determine the safe working pressure to be allowed, it becomes necessary to consider all the details of construction and complete information relative to the boiler must be had in order to reach a satisfactory conclusion.

A good starting point is the longitudinal joint. There are two general types of joint available: the lap joint and the double-strap butt joint. Each has its proper application and the use of a lap joint when a butt joint only should be considered has had disastrous results in numerous cases.

Each type may be single-, double-, triple- or quadruple-riveted and the efficiency of the joint increases with the number of rows of rivets used. The efficiency of a joint is the fraction that expresses the ratio of the strength of the joint to the strength of the solid plate.

A joint may fail in one of a number of possible ways, and the smallest of these resistances denotes the strength of the joint. A common formula used to determine the efficiency of a joint is

$$Efficiency = \frac{p - d}{p}$$

in which

p = Long pitch, or pitch of outside row, in inches;
d = Diameter of rivet hole, in inches.

The formula is based on the assumption that the weakest part of the joint is its resistance to tearing along the outside row of rivets. Thus, if t is the thickness of the plate in inches, and $T.\ S.$ the tensile strength of the steel in pounds per square inch, then the strength R_t of the joint to resist failure by tearing between the rivets in the outside row is

$$R_t = t \times (p - d) \times T.\ S.$$

Using the same notation, the strength R of the solid plate is

$$R = t \times p \times T.\ S.$$

The ratio of the strength of the joint to the strength of the solid plate, or the efficiency, is then

$$Efficiency = \frac{R_t}{R} = \frac{t \times (p - d) \times T.\ S.}{t \times p \times T.\ S.} = \frac{p - d}{p}$$

It is not always safe to assume that the weakest part of the joint is the resistance to tearing along the outside row of rivets. A properly designed joint should be equally strong to resist failure in any of the probable ways, and it is not always possible to say beforehand exactly what resistance will be least, because slight variations from computed dimensions are necessary to adapt the design to commercial sizes of rivets and fabricating machines.

In the lap joint the pitch in the successive rows of rivets is the same; hence, the strength of the joint is determined by the resistance to the shearing of all the rivets, the crushing of the plate before all of the rivets or the tearing of the plate along the outside row of rivets.

In the double-strap butt joint, the pitch of the rivets in single shear doubles in each successive row and it becomes possible for the joint to fail through some combination of tearing, crushing and shearing. For instance, the rivets in the outside row may shear and the plate tear along an inner row. It may be said, however, that in most cases the weakest part of a butt joint is its strength to resist failure by tearing along the outside row of rivets. Hence, the efficiency of the butt joint is generally given by the formula

$$Efficiency = \frac{p - d}{p}$$

In investigating a joint, a unit section only need be considered since this detail is repeated throughout the length of the seam. The unit section is the part of the joint included between the circumferential center lines of the rivets in the outside row. The part on either side of the longitudinal center lines of the joint may be considered.

It sometimes happens that in the manufacture of a boiler made up of two or more rings of unequal length the layer-out will make the pitches in the rings slightly different in order to secure equal divisions in each longitudinal seam. This is hardly to be considered good practice but must be kept in mind in making an investigation.

The following table gives approximately the efficiencies to be expected from the joints specified and should be considered as a guide only. The actual efficiency may vary somewhat on either side of the value given.

Type of Joint	Efficiency Per Cent.
Single-riveted lap	60
Double-riveted lap	70
Triple-riveted lap	75
Double-riveted butt	80
Triple-riveted butt	85
Quadruple-riveted butt	94

Tables I and II give the bursting pressures of boilers varying in diameter from 30 to 96 in. and provided with the type of joints indicated. The safe working pressure can easily be arrived at by dividing the bursting pressure by the factor of safety to be allowed. These tables are useful as a guide and they also indicate the efficiency possible with a properly designed joint. In cases where the efficiency is found to differ greatly from that given in the table, the bursting pressure $B.\ P.$ must be computed separately by means of the formula

$$B.\ P. = \frac{t \times T.\ S. \times Eff.}{r}$$

in which the efficiency is expressed as a decimal and r is the radius of the shell in inches.

According to the A. S. M. E. Boiler Code, good practice requires that the minimum thickness of any boiler plate under pressure shall not be less than $\frac{1}{4}$ in. and that the minimum thickness of shell plates and dome plates after flanging shall be $\frac{1}{4}$ in. when the diameter of the shell is 36 in. or under; $\frac{5}{16}$ in. for diameters

over 36 in. to 54 in.; $\frac{3}{8}$ in. for diameters over 54 in. to 72 in., and $\frac{1}{2}$ in. when the diameter of the shell is over 72 inches.

Single-riveted lap joints of girth seams are likely to develop fire cracks. These cracks in the metal extend from the rivet hole to the outside edge of the plate, and their presence is often discovered in the first girth seam of horizontal return-tubular boilers. A fire crack

TABLE I. BURSTING PRESSURES FOR SHELLS MADE OF 60,000-LB. STEEL

Thickness, In.	Efficiency, Per Cent.	Diameter of Shell, In. 30	36	42	48	54	60	66	72	78	84	90	96
		Double-Riveted Lap Joints											
$\frac{1}{4}$	74	740	616	529	463	410	370	336	308	284	264	247	231
$\frac{5}{16}$	72	900	750	643	562	500	450	409	375	346	321	300	281
$\frac{3}{8}$	70	1050	875	750	656	583	525	477	438	404	375	354	328
$\frac{7}{16}$	70	1225	1020	875	766	681	612	557	510	471	438	408	383
$\frac{1}{2}$	68	1360	1133	971	850	756	680	618	567	523	486	453	425
		Triple-Riveted Lap Joints											
$\frac{1}{4}$	77	770	641	550	481	428	385	350	321	296	275	257	241
$\frac{5}{16}$	76	950	791	679	594	528	475	432	396	365	339	317	297
$\frac{3}{8}$	75	1125	938	804	703	625	562	511	469	433	402	375	352
$\frac{7}{16}$	75	1312	1093	937	820	730	656	597	547	505	470	437	410
$\frac{1}{2}$	75	1500	1250	1071	938	833	750	682	625	577	536	500	469
		Double-Riveted Butt Joints											
$\frac{1}{4}$	83	830	689	593	519	461	415	377	346	319	296	277	259
$\frac{5}{16}$	83	1038	864	742	648	576	519	472	432	399	370	346	324
$\frac{3}{8}$	83	1245	1038	889	778	692	623	566	519	479	445	415	390
$\frac{7}{16}$	83	1452	1210	1037	908	807	726	660	605	559	519	484	454
$\frac{1}{2}$	82	1640	1367	1172	1025	911	820	745	683	631	586	547	513
		Triple-Riveted Butt Joints											
$\frac{5}{16}$	88	1100	917	786	688	611	550	500	458	423	393	366	344
$\frac{3}{8}$	87.5	1312	1094	937	820	729	656	597	547	505	469	438	410
$\frac{7}{16}$	86	1505	1254	1075	941	836	753	684	627	578	538	502	470
$\frac{1}{2}$	86.6	1732	1443	1237	1083	962	866	787	722	666	619	577	538
$\frac{9}{16}$	85.4	1921	1601	1372	1201	1068	961	873	801	739	686	640	600
$\frac{5}{8}$	84	2100	1750	1500	1313	1167	1050	955	875	808	750	700	656
		Quadruple-Riveted Butt Joints											
$\frac{1}{2}$	94.6	..	1183	1014	887	788	710	645	591	546	507	473	443
$\frac{9}{16}$	94	..	1371	1175	1028	914	823	748	685	633	588	548	514
$\frac{5}{8}$	94	..	1567	1343	1175	1044	940	855	783	723	671	627	588
$\frac{11}{16}$	94	..	1762	1511	1322	1175	1057	961	881	836	755	705	661
$\frac{3}{4}$	93.5	..	1948	1670	1461	1297	1168	1062	974	899	834	766	730

is not necessarily serious until it begins to show signs of leakage and in most cases an attempt to stop the leakage by calking only results in making matters worse. Often a leak may be stopped by cutting out the rivet and driving one with a larger head. However, the most satisfactory job is secured by removing the rivet and carefully welding up the crack, after which the hole should be reamed out and a new rivet driven.

Too much stress cannot be laid on the fact that the longitudinal joint of all shells for power boilers more than 36 in. in diameter should be of the double-strap butt construction. Whenever lap-joint construction is used in shells 36 in. in diameter or under, a pressure in excess of 100 lb. should not be permitted. However, the longitudinal joints on heating boilers in which the pressure does not exceed 15 lb. per sq.in. may be of lap construction on shells not exceeding 60 in. in diameter; above this, longitudinal joints should be double-strap butt joints.

Staying heads and flat surfaces in the boiler and furnace is too complex to be treated thoroughly in a general article. However, several leading features may be profitably dwelt upon, and the reader is referred to the A. S. M. E. Boiler Code for a more comprehensive treatment.

Segments of tube sheets in horizontal return-tubular boilers above the tubes are generally supported from the shell by means of diagonal braces of which there are a variety of forms. The crow-foot brace is probably the most familiar. The staying power of a diagonal brace depends upon the angle which it makes with the shell, being less or more as this angle is large or small, respectively. An accurate solution to determine the pressure a stayed head will withstand would involve finding the exact angle between the shell and each stay and computing the staying power of each separately. This would be a laborious process, and a sufficiently accurate solution may be arrived at by assuming that all stays make a maximum angle of 35 deg. with the shell and the corresponding maximum staying power of each becomes 0.8 times its safe strength in direct tension. Then, if n is the number of stays and L the safe strength of each in direct tension, the total staying power is $n \times 0.8L$. This is the total pressure that can be permitted safely on the stayed surface. Hence, if P is the pressure per square inch and A the area of the surface stayed in square inches, the total pressure is $A \times P$. It follows that $A \times P = n \times 0.8L$, or

$$P = \frac{0.8 \times n \times L}{A}$$

The area A is that included between lines drawn 3 in. from the shell and 2 in. above the tubes. To facilitate the determination of this area, tables have been prepared from which it can be read directly, when the diameter of the boiler and the vertical distance from the top of the top row of tubes to the shell is known. Table III, reproduced herewith from the A. S. M. E. Boiler Code, gives the area to be braced in tube sheets of shell boilers.

To determine the value for L in the formula for the allowable pressure on stayed tube sheets, it is necessary to know the type of stay used and also the material of which it is made. Table IV, also taken from the A. S. M. E. Boiler Code, gives the unit stresses to be employed in computing the strength of the various stays. The ordinary weldless diagonal stay used for bracing the top segments of tube sheets will ordinarily be embraced by line b, column 1, and allowed a fiber stress of 9500 lb. per square inch.

TABLE II. BURSTING PRESSURES FOR SHELLS MADE OF 55,000-LB. STEEL

Thickness, In.	Efficiency, Per Cent.	Diameter of Shell, In. 30	36	42	48	54	60	66	72	78	84	90	96
		Double-Riveted Lap Joints											
$\frac{1}{4}$	74	678	565	484	424	377	339	308	282	261	242	226	212
$\frac{5}{16}$	72	765	638	546	478	425	383	348	319	294	273	255	239
$\frac{3}{8}$	70	963	802	687	602	535	481	437	401	370	344	321	301
$\frac{7}{16}$	70	1123	936	802	702	624	561	510	468	432	401	374	351
$\frac{1}{2}$	68	1247	1039	890	779	693	623	567	519	479	445	416	390
		Triple-Riveted Lap Joints											
$\frac{1}{4}$	77	706	588	504	441	392	353	321	294	271	252	235	221
$\frac{5}{16}$	76	871	726	622	544	473	435	396	363	335	311	290	272
$\frac{3}{8}$	75	1031	859	737	645	573	516	469	430	397	367	344	322
$\frac{7}{16}$	75	1203	1003	859	752	668	602	547	501	463	387	401	376
$\frac{1}{2}$	75	1375	1146	982	859	764	687	625	573	529	434	458	430
		Double-Riveted Butt Joints											
$\frac{1}{4}$	83	760	634	543	476	423	380	346	317	293	272	254	238
$\frac{5}{16}$	83	951	793	679	594	527	476	432	396	366	340	317	297
$\frac{3}{8}$	83	1141	951	815	713	634	571	519	476	439	408	380	357
$\frac{7}{16}$	83	1331	1110	951	832	740	666	605	555	512	471	444	416
$\frac{1}{2}$	82	1503	1253	1074	940	834	752	683	626	578	537	503	470
		Triple-Riveted Butt Joints											
$\frac{5}{16}$	88	1008	840	720	630	560	504	458	420	388	360	336	315
$\frac{3}{8}$	87.5	1203	1003	859	752	668	602	547	501	463	430	401	376
$\frac{7}{16}$	86	1380	1150	985	862	766	690	627	575	531	493	460	435
$\frac{1}{2}$	86.6	1588	1323	1134	992	882	794	722	662	611	567	529	496
$\frac{9}{16}$	85.4	1761	1468	1258	1101	978	881	801	734	677	629	587	550
$\frac{5}{8}$	84	1925	1604	1375	1203	1069	963	875	802	740	688	642	602
		Quadruple-Riveted Butt Joints											
$\frac{1}{2}$	94.6	1301	1084	929	813	723	650	591	542	500	465	433	406
$\frac{9}{16}$	94	1508	1257	1077	942	838	754	685	628	580	539	502	471
$\frac{5}{8}$	94	1723	1436	1231	1077	957	862	783	718	663	615	574	539
$\frac{11}{16}$	94	1938	1616	1385	1212	1077	969	881	808	746	692	646	609
$\frac{3}{4}$	93.5	2143	1785	1530	1339	1190	1071	974	893	824	765	714	670

By referring to Table V the safe direct loads on stays at various fiber stresses can be read directly, those for a 9500-lb. stress appearing in the last column.

With this information at hand no difficulty should be experienced in determining the safe working pressure to be allowed on any tube sheet. For example, take a boiler 72 in. in diameter, provided with ten 1¼-in. round,

weldless crow-foot stays. The distance from the top of the tubes to the shell is 24 in. Referring to Table III it is seen that A equals 814 sq.in. and from Table V, L equals 11,658 lb. Hence,

$$P = \frac{0.8 \times 10 \times 11{,}658}{814} = 115\ lb.$$

In investigating the staying of a flat surface, it is not sufficient that the stays alone be strong enough,

TABLE III. NET AREAS OF SEGMENTS OF HEADS

Hgt. from Tubes to Shell, In.	Diameter of Boiler, In. 24	30	36	42	48	54	60	66	72	78	84	90	96
	Area to be Stayed, Sq. In.												
8	28	33	37	40	43	47	51	53	55	58	60	63	65
8½	35	41	46	51	55	59	63	66	70	74	76	80	82
9	42	49	56	62	67	72	76	82	86	90	92	95	98
9½	50	58	66	70	80	86	91	96	101	105	111	116	119
10	57	68	77	85	93	99	106	112	117	123	129	132	137
10½	66	78	89	98	107	114	123	131	135	142	147	153	160
11	74	88	100	111	121	130	138	147	155	161	169	174	183
11½	83	99	112	124	137	146	156	165	173	181	189	196	204
12	91	109	125	139	151	163	174	184	194	203	213	219	230
12½	....	120	138	153	167	180	193	204	216	224	234	243	252
13	....	132	151	168	183	197	211	224	235	247	256	267	279
13½	....	143	164	183	200	216	230	246	258	270	282	293	302
14	....	155	178	199	217	234	250	266	280	294	305	319	331
14½	....	167	192	215	235	254	271	287	303	318	333	345	360
15	....	178	206	231	252	273	291	309	326	343	357	372	386
15½	....	....	220	247	271	291	312	332	350	368	382	400	417
16	....	....	235	263	289	312	334	355	374	394	411	423	443
16½	....	....	249	281	308	332	357	380	399	420	436	457	475
17	....	....	264	297	326	353	378	402	425	447	467	486	502
17½	....	....	....	314	345	374	400	426	449	471	494	516	536
18	....	....	....	331	365	396	424	450	476	500	520	543	564
18½	....	....	....	349	384	417	448	476	501	526	552	577	598
19	....	....	....	366	404	439	470	500	529	555	580	604	631
19½	....	....	....	384	424	461	496	528	558	584	613	641	663
20	....	....	....	401	444	483	519	552	583	613	642	667	699
20½	....	....	....	....	464	505	543	578	613	643	675	706	729
21	....	....	....	....	485	528	568	604	640	673	705	733	766
21½	....	....	....	....	505	551	594	632	669	703	739	766	797
22	....	....	....	....	526	574	618	658	697	734	769	800	835
22½	....	....	....	....	....	597	643	687	726	765	800	835	867
23	....	....	....	....	....	620	668	713	754	796	830	869	906
23½	....	....	....	....	....	642	695	740	784	827	866	904	945
24	....	....	....	....	....	667	719	768	814	859	897	939	978
24½	....	....	....	....	....	689	745	797	843	892	934	975	1018
25	....	....	....	....	....	714	771	825	875	922	966	1010	1051
25½	....	....	....	....	....	737	798	855	907	956	1003	1047	1092
26	....	....	....	....	....	761	824	882	936	987	1035	1083	1126
26½	....	....	....	....	....	....	850	909	968	1024	1073	1120	1167
27	....	....	....	....	....	....	877	939	998	1053	1106	1157	1202
27½	....	....	....	....	....	....	904	968	1030	1089	1145	1195	1243
28	....	....	....	....	....	....	930	997	1060	1120	1177	1232	1279
28½	....	....	....	....	....	....	....	1028	1092	1157	1211	1270	1321
29	....	....	....	....	....	....	....	1056	1123	1187	1248	1305	1360
29½	....	....	....	....	....	....	....	1084	1155	1221	1284	1347	1400
30	....	....	....	....	....	....	....	1115	1187	1255	1321	1382	1442
30½	....	....	....	....	....	....	....	....	1218	1290	1358	1424	1480
31	....	....	....	....	....	....	....	....	1252	1324	1394	1459	1523
31½	....	....	....	....	....	....	....	....	1286	1359	1433	1496	1561
32	....	....	....	....	....	....	....	....	1317	1394	1467	1538	1605
32½	....	....	....	....	....	....	....	....	....	1430	1508	1575	1650
33	....	....	....	....	....	....	....	....	....	1465	1542	1617	1687
33½	....	....	....	....	....	....	....	....	....	1500	1578	1655	1733
34	....	....	....	....	....	....	....	....	....	1536	1617	1695	1770
34½	....	....	....	....	....	....	....	....	....	....	1654	1735	1816
35	....	....	....	....	....	....	....	....	....	....	1692	1775	1856
35½	....	....	....	....	....	....	....	....	....	....	....	1810	1900
36	....	....	....	....	....	....	....	....	....	....	....	1857	1941
36½	....	....	....	....	....	....	....	....	....	....	....	....	1984
37	....	....	....	....	....	....	....	....	....	....	....	....	2026

but in addition they must not be placed too far apart. The maximum spacing between the points of attach-

TABLE IV. MAXIMUM ALLOWABLE STRESSES FOR STAYS AND STAYBOLTS

Description of Stays	Stress, Lb. per Sq. In. For Lengths between Supports not Exceeding 120 Diameters	For Lengths between Supports Exceeding 120 Diameters
a Unwelded stays less than twenty diameters long screwed through plates with ends riveted over	7500	....
b Unwelded stays and unwelded portions of welded stays, except as specified in line *a*	9500	8500
c Welded portions of stays	6000	6000

ment of diagonal braces to the braced surface should be determined by the formula

$$p = \frac{11.6\,t}{\sqrt{P}}$$

in which

p = Distance between stays in inches;

t = Thickness of plate in sixteenths of an inch;

P = Pressure in pounds per square inch.

When investigating a given case to determine the maximum allowable pressure, a more convenient form of the equation is

$$P = \frac{135\,t^2}{p^2}$$

Thus, if the tube sheet in the 72-in. boiler just referred to is $\frac{9}{16}$ in. and the minimum distance apart of the crow-foot braces is 10 in., the maximum allowable pressure is

$$P = \frac{135 \times 9^2}{10^2} = 109\ lb.$$

Again referring to the Boiler Code, good practice prescribes the following limits for the minimum thickness of tube sheets in shell boilers: When the diameter of the tube sheet is 42 in. or under, $\frac{3}{8}$ in.; over 42 in. to 54 in., $\frac{7}{16}$ in.; over 54 in. to 72 in., $\frac{1}{2}$ in.; over 72 in., $\frac{9}{16}$ inch.

TABLE V. ALLOWABLE LOADS ON ROUND BRACES OR STAY RODS

Minimum Diameter of Circular Stay, In.	Net Cross-Sectional Area of Stay, Sq.In.	Allowable Stress, in Lb. per Sq.In. of Net Cross-Sectional Area: 6,000	8,500	9,500
		Allowable Load, in Lb., on Net Cross-Sectional Area		
1	1.0000	0.7854	4,712	6,676	7,462
1 1/16	1.0625	0.8866	5,320	7,536	8,423
1 1/8	1.1250	0.9940	5,964	8,449	9,443
1 3/16	1.1875	1.1075	6,645	9,414	10,521
1 1/4	1.2500	1.2272	7,363	10,431	11,658
1 5/16	1.3125	1.3530	8,118	11,501	12,854
1 3/8	1.3750	1.4849	8,909	12,622	14,107
1 7/16	1.4375	1.6230	9,738	13,796	15,419
1 1/2	1.5000	1.7671	10,603	15,020	16,787
1 9/16	1.5625	1.9175	11,505	16,298	18,216
1 5/8	1.6250	2.0739	12,443	17,628	19,702
1 11/16	1.6875	2.2365	13,419	19,010	21,247
1 3/4	1.7500	2.4053	14,432	20,445	22,852
1 13/16	1.8125	2.5802	15,481	21,932	24,512
1 7/8	1.8750	2.7612	16,567	23,470	26,231
1 15/16	1.9375	2.9483	17,690	25,061	28,009
2	2.0000	3.1416	18,850	26,704	29,845
2 1/8	2.1250	3.5466	21,280	30,147	33,693
2 1/4	2.2500	3.9761	23,857	33,797	37,773
2 3/8	2.3750	4.4301	26,580	37,656	42,086
2 1/2	2.5000	4.9087	29,452	41,724	46,632
2 5/8	2.6250	5.4119	32,471	46,001	51,413
2 3/4	2.7500	5.9396	35,638	50,487	56,426
2 7/8	2.8750	6.4918	38,951	55,181	61,673
3	3.0000	7.0686	42,412	60,083	67,152

Carling Turbo Blower

Another turbo blower for producing draft in boiler furnaces is known as the Carling turbo blower and is manufactured by the Carling Turbine Blower Co., Worcester, Mass. In general, this machine is similar to other turbo blowers, and the fan casing is designed on the venturi principle which allows a free flow of

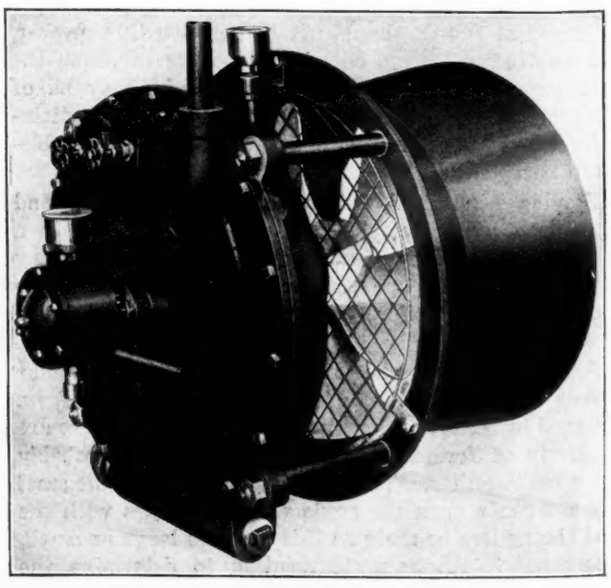


FIG. 1. CARLING TURBINE BLOWER

air, gives high efficiency and makes the blower practically noiseless in operation.

At one end of the shaft is a turbine, the casing of which is constructed with a safety ring in combination with the turbine cover, so that damage by excessive rotor speed is prevented. The turbine cover contains a steam chamber, nozzle port and controlling valve. A removable plug is placed opposite each nozzle to allow inspection. The construction of the turbine is such that

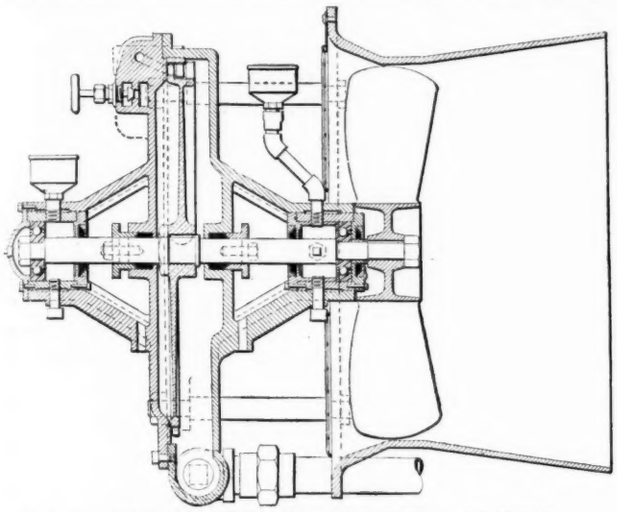


FIG. 2. SECTION THROUGH THE TURBO BLOWER

a back pressure up to 15 lb. may be carried, and the exhaust-steam connection is designed so that it may be diverted from the ashpit and piped to a feed-water heater if desired. Each blower is supplied with a steam strainer to prevent scale and other foreign matter from getting into the nozzles and clogging them.

The controlling valves close against the steam pressure, thus allowing them to be packed without shutting down the blower. The nozzles are made of tobin bronze and are so inserted in the casings that they cannot work loose and get into the rotor blading. The rotor is made of phosphor bronze and is of the impulse type. The blades are of cupro nickel and are so inserted in the rotor that they cannot work loose. They are further protected by a band riveted around the entire periphery.

The stuffing-boxes are cast to go with turbine casing and cover, and anti-friction metallic packing is used in them.

Two bearings are used with the turbine rotor supported between them. They are of the ball-bearing type.

The fan is made of aluminum, the pitch of the blade being such as to give the maximum amount of air with the least expenditure of power. The blade is placed against the inner bearing and secured to the shaft with a key, being held against the shoulder on a shaft with a nut.

What Force Does a Float Exert?

The ball float is a very common device used in power plants to indicate the level of liquid in a tank or to shut the inlet valve when the liquid level has reached a desired height. It is arranged so as to operate a sliding pointer or a lever, and so it must be capable of exerting force enough to overcome the frictional and other resistance

It is not a difficult matter to find out the force that a float of a given size will exert. The reason a body of any kind floats on water is because it weighs less than an equal volume of water. A ball float resting freely on the surface of water is only partly submerged in the water, and the weight of the water it displaces is equal to its own weight.

When the ball is resting freely on the water, the water is pressing upward against it and this upward pressure is exactly equal to the weight of the ball. The two pressures or forces are directly opposed to each other, and so they balance. The result is that the ball floats.

If you press down on the ball, it will sink deeper, and the deeper it sinks the greater will be the pressure required to keep it down, until the ball is forced under the surface. It will then push upward with the same force, no matter how far it may be submerged.

In any case the upward pressure is equal to the difference between the upward pressure of the water and the downward pressure due to the weight of the ball. Let us assume a case to illustrate the point. Suppose that the ball is 6 in. in diameter outside and that it weighs 1 lb. and let it be required to find the upward force or pressure when the ball is completely under water.

The upward pressure of the water is equal to the weight of water displaced by the float. In this case it would be the weight of water in a sphere 6 in. in diameter. A sphere of this size has a volume of $0.5236 \times 6^3 = 0.5236 \times 6 \times 6 \times 6 = 113$ cu.in. A cubic inch of water weighs about 0.036 lb. and so the weight of water displaced by the ball is $113 \times 0.036 = 4$ lb., nearly.

The water presses upward with a force of 4 lb. against the float, and the weight of the float acts downward with a force of 1 lb. Then, the pressure that the float exerts upward is the difference or $4 - 1 = 3$ lb., and this is the pressure that would be required to hold the float under water. When this pressure is removed, the ball rises out of the water and floats on the surface, and while it thus floats it exerts no upward force. The upward and downward forces are then balanced, and their difference is zero.

The Wadsworth Boiler Explosion at Detroit

By J. C. McCabe*

The boiler that exploded at the plant of the Wadsworth Manufacturing Co. in Detroit on the morning of Nov. 1 was being operated to furnish steam to the McCord Manufacturing Co. at the war-work plant just adjacent to the boiler house. The boiler plant consisted of four 72 in. x 18 ft. horizontal-tubular boilers which were banked over night and had no attention outside of the casual visit of the watchman.

The accompanying steam chart shows the pressure on the boiler over night. It will be noticed that at between 4 and 6 there was a slight drop in pressure, but that shortly after 6 o'clock, the pressure rose again at "*A*," but dropped off sharply. This was due to the turning of steam onto the heating system of the McCord Manufacturing Co. It appears that the fire must have

*Chief Inspector and Engineer, Bureau of Safety Engineering, City of Detroit.

been broken up, as steam was carried with less weight of drop for a period of about fifteen minutes. Thereafter the pressure dropped very rapidly.

It is stated the explosion happened at about 10 minutes to 8 in the morning, but this is doubtful, if the chart was placed correctly on the clock. We found that the scale had been loosened from the upper tubes, and precipitated to the shell. This was evidently caused by failure to keep a proper level of water in the boiler. The plate used in this boiler is $\frac{17}{32}$ in. in thickness. The boiler was made of two rings, each would be possible to heat these tubes to 800 deg. before a set in compression would take place in the tube ends. The scale on the tubes was pretty hard and would lend itself readily to casting off the increased temperature of the tube.

The line near "*B*" was thought to be caused by the shock of the failure of the boiler. I fail to see how there could be any such reaction. The rupture was mildly progressive and would naturally be attended with a constant drop in pressure. The line was probably made in the removal of the chart. The brickwork on

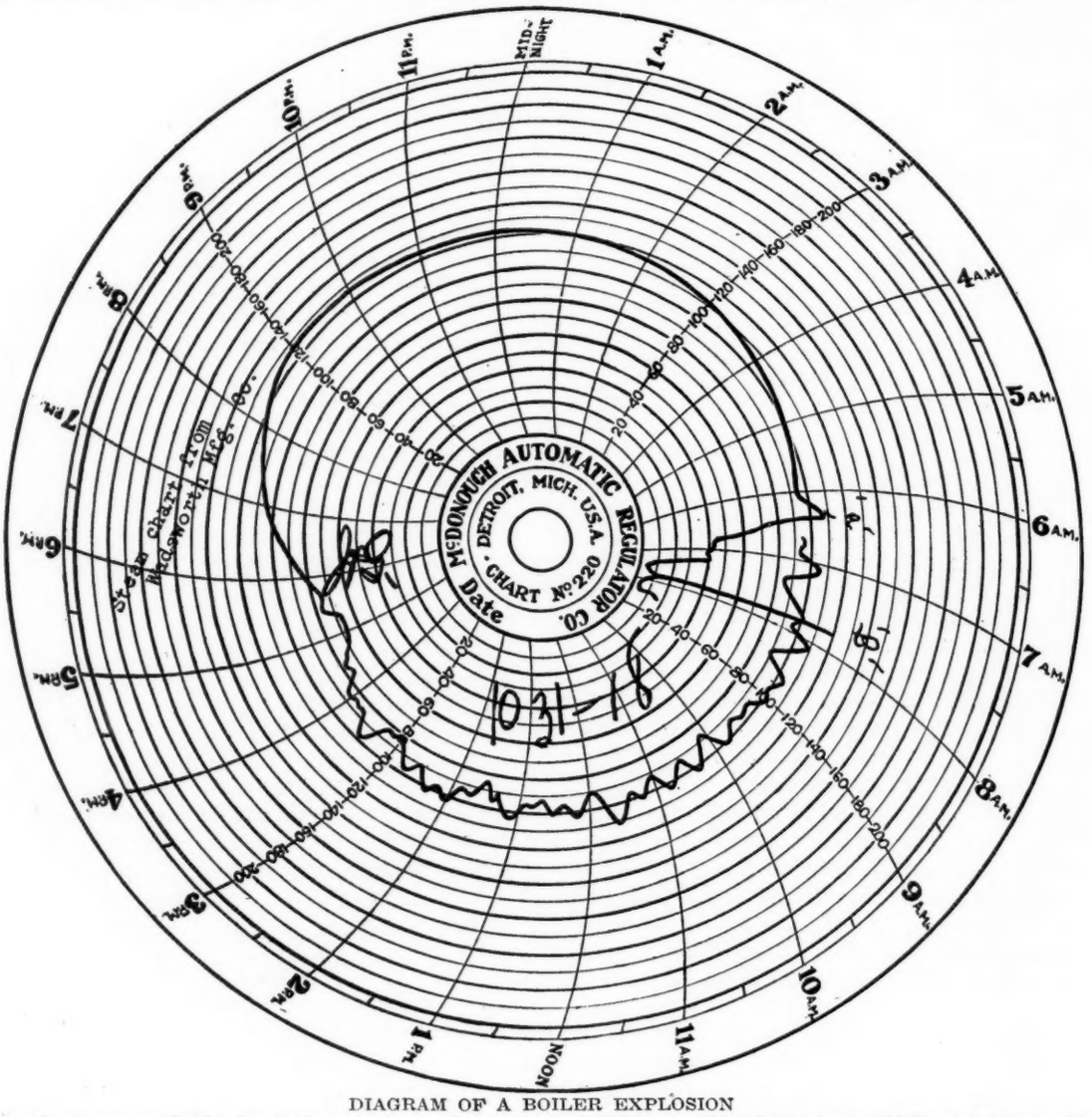


DIAGRAM OF A BOILER EXPLOSION

The drop of pressure probably due to the rupture is shown at about 7:10 a.m. The sharp rise to 120 lb. at 7:50, at which time the explosion is said to have occurred, may have been made in removing the chart

9 ft. long over all. The rupture in the shell occurred 14 in. to the left of the vertical center of the boiler, and was 4 ft. 6 in. in length. The edges of the plate were drawn down to about one-eighth of an inch in thickness.

In my opinion this failure occurred when the steam was at 40 lb., the plate reaching a temperature of 1800 deg. or thereabouts. From the location of the rupture I surmise that the boiler was being fired principally on the right-hand side of the furnace. The tubes were tight, there being no evidence of excessive overheating. Tests that I have made show that it

the left-hand side of the boiler was washed out by the discharge of water from the boiler. The boiler was suspended on steelwork and inclosed with a sheet-metal casing.

Four men in the boiler room were severely scalded, but the latest reports indicate that they will fully recover. The accident was due to the fact that the engineer in charge of the boiler allowed excessive scale to accumulate on the tubes and this was thrown down on the fire sheets, allowing them to become overheated. It also appears that the man in charge of the boiler at the time of the accident was unlicensed.

Oliver Evans, Inventor and Mechanic*

By JAY M. WHITHAM

OLIVER, the son of Charles Evans, was born about two and one-half miles northwest of the village of Newport, Del., in 1755, and died in New York City Apr. 15, 1819, at the age of 64. He spent about the last thirty years of his life in Philadelphia. He began his apprenticeship to a wheelwright at the age of 18, and soon manifested signs of his inventive endowment. At the age of 22 he invented two machines for making wool and cotton cards and perfected one so as to produce 3000 card teeth per minute. This invention yielded so little personal return that he abandoned a plan for a machine to set these teeth ready for use.

In 1782 he with two of his seven brothers contracted to build a merchant flourmill in New Castle Co., Delaware, and in the fall of 1783 he left his store in Queen Anne's Co., Maryland, to superintend its construction.

OLIVER EVANS

Evans was not a miller or millwright and proceeded to study the art. At that time the millstone was driven by power, and all the other operations were performed by manual labor. He invented mechanisms that made the mill automatic, as it were, so that one man did the work formerly requiring three men and a boy. His inventions were: The bucket elevator or endless belt with buckets, for raising the grain or meal to any desired height; the screw conveyor, which carried the grain or meal horizontally from one position to another; the hopper-boy which spread the meal on the loft floor and stirred it while cooling, so that it might be more quickly prepared for bolting; and the drill or drag conveyor, which was a belt with flights or rakes.

In September, 1784, Evans declared his purpose of constructing a 20-barrel mill embodying these inventions, and on Sept. 5, 1785, this mill was started. It fulfilled his expectations, but was ridiculed and discountenanced by the millers along the Brandywine, who termed Evans' mechanisms "wooden millers," and his mill as containing "a set of rattletraps."

In 1787 patents for these improvements in milling were issued to Evans by the legislatures of Pennsylvania, Delaware, Maryland and New Hampshire. He met the sorry fate usual to inventors. Millers stole his designs and his only recourse was the law. It is doubtful if his entire royalties compensated him for a year's personal effort.

Evans brought out his "Young Millwright and Miller's Guide," in Philadelphia in 1795. He was an inventor and mechanic, and never claimed to be a miller or a millwright. The preface to this book states:

> The reason why a book of this kind, although so much wanted, did not sooner appear, may be because they who have been versed in science and literature have not had practice and experience in the arts; and they who have had practice and experimental knowledge have not had time to acquire science and theory, those necessary qualifications for completing the system, and which are not found in any one man. Sensible of my deficiencies in both, I should not have undertaken it was I not interested in the explanations of my own inventions. I have applied to such books and men of science as I expected assistance from, in forming a system of theory; and to practical millwrights and millers for the practice.

After about 1791 Evans lived in Philadelphia and kept a flour store and supply depot for the sale of millstones, bolting cloths, rolling screens, ironwork, stones for gudgeons for merchant and country mills, etc. He also sold the right to use his milling inventions at the rate of $40 for each run of stones, or $10 each for the use of his four inventions.

Evans' 1795 edition of his book consisted of 2000 copies, "some few of which were sold at $3." He says: "My agents carried them to show to millers and millwrights, and gave away a great proportion of the edition to them, by orders from me, for the purpose of getting my improvements introduced. One of my agents traveled for thirteen years, to instruct millwrights and millers to make and use the improvements and to sell licenses, and rode about 100,000 miles on that business."

Aside from selling licenses Evans devoted little attention to milling after 1791, but directed his talents toward steam engineering. As a boy of 18 he had schemed out the propulsion of vehicles by steam power and had invented a "powerful steam engine" prior to 1787, when the legislatures of Maryland and New Hampshire granted patents for his steam engine and steam-propelled carriages. In 1801 he began the construction of his engine and had it in operation in the winter of the following year. It cost $2000, besides his time and labor, which he placed at $1000. The engine's performance excited "considerable attention and curiosity."

In 1803 Evans became the first manufacturer of steam engines in Philadelphia. His engine designs were named the "Columbian," the "Inexhaustible" and the "Volcanic." His first engine (1803) drove 12 saws, cutting stone at the rate of 120 ft. in 12 hours, or 2 in. per minute.

Evans' offer of Sept. 26, 1804, to construct steam-propelled vehicles for the managers of the Philadelphia and Lancaster Turnpike was rejected.

*In preparing this outline the following publications were freely consulted: Evans' "Young Millwright and Miller's Guide," 1795; Moore's "Universal Assistant and Complete Mechanic," 1880; Latimer's "Sketch of the Life of Oliver Evans," 1872, as published in "Harkness' Magazine," and "Power," for Sept. 15, 1914; also Bennett and Elten's "History of Corn Milling," Vol. 2, 1899.

In order to exploit his engines, he wrote "The Young Steam Engineer's Guide," which he termed "as abstruse and difficult a work as was ever published." This was in 1804 or 1805.

At this time Evans and John Stevens, of Hoboken, N. J., had a sharp controversy, which resulted in establishing that Evans had not stolen Stevens' "powder," or appropriated his ideas, but rather the reverse.

Evans published on Oct. 5, 1805, his "Abortion of the Young Steam Engineer's Guide" to meet the arguments of his opponents. It contained: "An investigation of the principles, construction and powers of steam engines; a description of a steam engine on new principles, rendering it much more powerful, more simple, less expensive, and requiring much less fuel than an engine of the old construction. A description of a machine, and its principles, for making ice and cooling water in large quantities in hot countries, to make it palatable and wholesome for drinking, by the power of steam; invented by the author; and a description of four other patented inventions." The appendix contained his controversy with Stevens.

When Evans was 51 years of age, the United States Circuit Court having ruled that to grant a patent for a useful invention would be "an infringement of the public right," in a fit of vexation and despair, and in spite of the protests and entreaties of his family, he destroyed the drawings and specifications of eighty inventions and discoveries, so "that he might pursue the means of procuring an honest livelihood without 'infringing the public rights.'"

In October, 1807, Judges Washington and Peters in the Federal Court nonsuited Evans as his patents for engines were not properly described. Congress in January, 1808, corrected this delinquency by granting him a patent for 14 years. This stimulated his efforts. He built no less than twenty-five engines which were operated in Pittsburgh, Natchez, Cincinnati, Louisville, Frankfort, Lexington, Middletown, Conn., Providence, R. I., etc. He also endeavored to reconstruct, from the ashes, the inventions and specifications that he had destroyed.

Evans never forgave Thomas Jefferson for his attitude on patents, as Jefferson's theory made Archimedes the inventor of Evans' conveyor. Evans claimed that the applier of the invention or discovery is entitled to the patent.

In 1804 he had a contract for a power dredge, or "amphibious digger," for the harbor of Philadelphia. He constructed it to operate a chain of buckets by means of a 5-hp. engine on a scow 30 ft. long by 12 ft. Prior to this time dredging had been done by manual labor. The engine had a 5-in. cylinder and a 19-in. stroke. Evans placed wheels under this boat and propelled it by steam a mile and a half up Market St., Philadelphia, around what is now the City Hall, and thence to the Schuylkill, where he removed the wheels, placed a stern paddle-wheel in position and drove the steamboat down the Schuylkill, into the Delaware, and up to Philadelphia, a distance of 16 miles "in the presence of thousands." As Galloway, the British engineer, has shown, this "fully establishes Evans' claim to the first contrivance of a practical steamboat," while it also made him the first to propel carriages by other than animal power.

In 1814, in a satire entitled "Patent Right Oppression Exposed," under an assumed name, Evans said:

> The time will come when people will travel in stages moved by steam engines, from one city to another, almost as fast as birds fly, fifteen or twenty miles in an hour . . . . A carriage will set out from Washington in the morning, the passengers will breakfast in Baltimore, dine at Philadelphia, and sup in New York, the same day. To accomplish this, two sets of rail-ways will be laid so nearly level as not in any place to deviate more than two degrees from a horizontal line; made of wood or iron, or smooth paths of broken stone or gravel, with a rail to guide the carriages, so that they may pass each other in different directions, and travel by night as well as by day; and the passengers will sleep in these stages as comfortably as they now do in steam stage boats.

On Apr. 11, 1819, the buildings on Ridge Road, Philadelphia, occupied by Evans as a foundry and factory, were wantonly set on fire by a lad about 20 years of age, and were destroyed. All of Evans' patterns and most of his property, valued at $15,000, were lost. This no doubt contributed to his death, which occurred four days later at the home of Elijah Ward in New York. His remains were interred in that city. He died poor and neglected, fitting the words of Franklin, "A man's useful inventions subject him to insult, robbery and abuse."

Oliver Evans was about 5 ft. 8 in. in height and rather portly, but active. Arnold, in an address in 1850 before the American Institute in New York, said: "Wherever the steam mill resounds with the hum of industry, whether grinding flour in his native Schuylkill or cutting logs in Oregon, there do you find a monument of Oliver Evans."

His life was that of the inventor—full of hopes and disappointments and with scanty remuneration. He was one of the greatest inventors in the world's history and is now so recognized in all countries. Had he received even some little encouragement and financial assistance, this country would have been much more rapidly developed industrially and commercially.

All of Evans' inventions were practical and commercially useful. He revolutionized milling the world over, and his system prevailed down to about 1870. It is said that he excelled Watt in the mechanical perfection of his engine design, and he has been called "the Watt of America." He made the first practical application of the engine to propulsion on land and on water. He pointed out ice and refrigeration possibilities by the aid of the steam engine. He conceived the sleeping car.

Unfortunately, the world will never know the depth and profundity of the endowment of Oliver Evans, whose life was full of disappointments.

The predominant contributor to the world's supply of petroleum, according to *The Engineer*, is the United States, which furnished no less than 64.74 per cent. of the estimated total for 1917, the others in order of importance being: Russia, with 13.26 per cent.; Mexico, with 11.37 per cent.; the Dutch East Indies, with 2.74 per cent.; Rumania, with 2.08 per cent.; India (Burma and Assam), with 1.61 per cent.; Persia, with 1.32 per cent.; Galicia, with 0.947 per cent.; Japan, with 0.615 per cent.; Peru, with 0.511 per cent.; Trinidad, with 0.303 per cent.; Germany, with 0.189 per cent.; Argentina, with 0.170 per cent.; Egypt, with 0.094 per cent.; Canada, with 0.037 per cent.; Italy, with 0.002 per cent.; and other countries, with 0.006 per cent.

Fuel And Its Economical Use

By E. A. UEHLING

THIS ARTICLE INDORSED BY

U. S. FUEL ADMINISTRATION

The author points out the necessity for burning fuel economically and emphasizes the point that the engineer should take the initiative in such work.

ANY substance that can be ignited and, when supplied with the required amount of oxygen, will generate more heat than is required to support its own combustion is a fuel. To be commercially useful, the cost per unit of weight or volume at the place of consumption must be less than the value of the available heat generated by its economical combustion. Commercial fuels may be gaseous, liquid or solid.

The gaseous fuels are natural gas, illuminating gas, water gas, producer gas, coke-oven gas and blast-furnace gas. There are a few other fuel gases, such as acetylene and hydrogen, but these are not used for the generation of power. Gaseous fuels are measured in cubic feet, and their heat value is rated in B.t.u. per cubic foot.

The liquid fuels are petroleum and its various derivatives, tar and alcohol. Liquid fuels are generally measured by the gallon or the barrel, and sometimes by the pound. The pound is convenient, from the standpoint of the engineer, since the heat value of liquid fuels is rated in B.t.u. per pound.

Gaseous and liquid fuels are used extensively for the direct generation of power by being burned in the cylinders of internal-combustion engines; but the total power produced in this way is small in comparison with that produced indirectly by the steam engine from the heat evolved by the combustion of fuel under a boiler.

The solid fuels are coal, lignite, peat, wood (including shavings, sawdust and tanbark), bagasse and straw. With the exception of wood, which is measured by the cord, all solid fuels are measured by the ton and pound. The use of wood for the production of steam is rapidly decreasing, except in the form of shavings, sawdust and other waste from wood-working industries. Tanbark is used to a limited extent in tanneries, and bagasse (which is what remains after the juice has been squeezed out of sugar cane) is used as a fuel under the boilers of sugar mills. Both tanbark and bagasse, because of their excessive moisture and low heat value, require specially designed furnaces to burn them successfully, and can be utilized profitably only at the plants that produce them. The use of straw as a fuel is insignificant. The only record of its application for power purposes is in the operating of threshing machines in localities where there is no wood and coal is very expensive and difficult to obtain. In comparison with coal all other fuels dwindle into insignificance in their application to the production of power.

The amount of coal remaining in the earth cannot be calculated with any degree of exactness, for there may still exist some large and many small undiscovered coal fields; also, the known fields may contain more or less coal than is indicated by their area and present yield per acre. What we do know is that the available coal supply of the world is limited, that it is being consumed at a rapidly increasing rate, and that it will sooner or later be exhausted. Whether this will be one hundred or a thousand years from now does not alter the fact. The day of exhaustion can be indefinitely postponed only by reducing the rate of consumption, and this will automatically take place because the cost will necessarily increase as the available supply diminishes.

Few people give this matter a thought, and fewer realize that our present state of civilization is dependent on mechanical power, nine-tenths of which is derived from the combustion of coal. The least concerned of all are those who are handling fuel wastefully and are thus more or less unconsciously hastening the approach of the time when there will be no coal to handle.

The best that it has been possible to accomplish through the medium of steam is to convert about 18 per cent. of the heat energy contained in the fuel burned under the boilers into power developed by the engine or turbine. The large, well-equipped and best-managed plants average below 15 per cent. The general average of all steam-power plants is below 10 per cent., and in poorly equipped and badly managed plants, as well as in small plants, less than 5 per cent. of the heat energy in the coal becomes available as power from the engine. It has been estimated that 180 million tons of coal is wasted in the United States each year, largely in power plants.

Reasons for Reducing Fuel Waste

More than 50 per cent. of the preventable heat loss in power plants occurs in the boiler room, and it is up to every operating engineer to cut down this waste to a minimum. His desire to do this should spring not so much from the altruistic motive to delay the evil day when there will be no more coal, as from a moral sense, because wanton waste of so necessary a commodity as coal is criminal. Aside from that, it is his duty to his employer to run his plant as economically as possible, and it is to his personal interest to do so.

By reducing the amount of coal burned to keep up the required steam pressure, the engineer lightens the labor and thereby enhances the good will of his firemen, which makes for greater effort in the right direction; or, if the boilers are stoker-fired, he creates greater interest and closer watchfulness on the part of the attendants. More economical operation of his plant increases the value of his services and makes the employer more inclined as well as better able to increase his pay. If the employer should prove unappreciative, the satisfaction of having done something worth while, something to be proud of, is worth a great deal. It enhances his self-respect, which is an asset so long as it does not degenerate into conceit, which is a liability and a handicap.

No doubt the majority of operating engineers believe

that because they produce all the steam required and no complaints are heard about the coal bills, their boilers are producing steam with a fair degree of efficiency. But that is no criterion as to fuel economy. Very few managers or proprietors bother about boiler efficiency so long as the power is forthcoming to run the plant, especially in these times when the profits are such that output counts for more than close economy.

Managerial Indifference to Coal Economy

The great majority of managers figure cost and profit wholesale. So long as the profits are satisfactory, there is no kick and no incentive to go into detail. It is generally satisfactory to divide the cost into the cost of raw material, labor, supplies, selling expense and overhead. Coal is included under the general head of raw material, which is bought at the lowest market price. Quality is not infrequently sacrificed to price. This is most likely to occur in the purchase of coal. On the face of it, the larger the amount of raw material consumed the greater will be the output of finished goods; therefore, there is no apparent incentive for the manager to investigate its consumption except as to price. For the sake of convenience in comparing the classified costs, they are generally expressed as percentages of the total cost. This method adds still further to the obscurity of the true cost relation and to the inability to locate points where waste occurs and to appreciate their importance.

Take, for example, a manufacturing establishment that produces one million dollars' worth of goods per annum at a cost of eight hundred thousand dollars. Forty thousand dollars' worth of coal is burned annually to produce the required power, light and heat. But forty thousand dollars is only 5 per cent. of the total cost. It is insignificant compared with the labor cost, which may be 50 or 60 per cent. The average manager is, or believes himself to be, kept amply busy with the larger phases of the affairs of the works he is supposed to be managing, which explains why the average operating engineer is permitted to continue his wasteful ways so long as he produces the necessary power and steam. That, however, is no excuse for the engineer to continue to waste fuel. He should not wait until pressure is brought to bear on him from the top. Pressure from above is depressing, even degrading, but pressure from below is elevating. The engineer in charge of a power plant should know and not guess at what is necessary to get the most steam with the least coal. He should not allow himself to be caught napping.

Opportunity for Improving Efficiency

The average efficiency of steam boilers throughout the country, it is safe to say, is below 60 per cent. There are a few boiler plants that operate with an efficiency of, or close to, 80 per cent., which shows what can be done with proper equipment and intelligent management. There are many more boilers being operated at an efficiency below 50 per cent. because of poor equipment or slovenly attendance, or both. But there are few boiler plants in which the coal consumption could not be reduced 10 per cent., and in many cases 25 per cent. or even more.

These are facts over which every operating engineer should ponder, and he should take the initiative in getting what is necessary to enable him to improve the economy of his plant. To do this he must be prepared to approach the manager in the right way and be properly fortified. If the engineer approaches the general manager reluctantly and tells him timidly that he believes that he might be able to make a saving of 10 per cent. on the coal consumption, without being able to give any definite reasons for his belief, and asks for the expenditure of a considerable sum of money for scientific instruments by the aid of which he hopes to accomplish the result, he will invariably be turned down. An engineer in that state of mind and that condition of unpreparedness is not likely to succeed in getting what he thinks he needs to secure better fuel economy. The manager is apt to ask him some embarrassing questions as to why he needs the equipment of instruments asked for; why he should not be able to get along with a simple Orsat apparatus, costing twenty-five or thirty dollars, instead of autographic CO_2 meters costing one hundred and fifty to two hundred dollars per boiler; why a simple draft gage costing ten or twelve dollars is not as good as a draft analyzer costing twenty-five; what the functions of the several instruments are, and so on. If the engineer cannot answer these very pertinent and appropriate questions, the chances that he will get what he needs are very small; or, if a progressive manager should force an equipment of scientific instruments on such an engineer, the chances are that the results expected would not materialize.

Percentage of Saving Not Impressive

On the other hand, a manager who is not sufficiently posted on technical matters to ask intelligent and pertinent questions will turn to his simplified cost sheet from which he sees at a glance that the cost of coal is only 5 per cent. of the cost of production, and he quickly figures that a saving of 10 per cent. on 5 per cent. is only ½ per cent. That does not impress him, especially in view of the considerable cost, which the engineer estimates at perhaps $1500. When the profits are satisfactory, a saving of ½ per cent. is not worth considering, and when the profits are small, the management thinks that it cannot afford the outlay. The timid and unprepared engineer, feeling not quite sure of himself or of the success of his proposition, comes away rather glad that he was turned down, since it relieves him of additional responsibility.

On the contrary, an engineer who is thoroughly posted on the conditions necessary for efficient combustion, on which boiler efficiency primarily depends, and acquainted with the function of each instrument of the equipment he wants will feel sure of himself and will be able to give an intelligent and convincing answer to any question the skeptical manager may ask. Such an engineer will not timidly approach the manager and ask for an equipment of scientific instruments costing about $1500, by the aid of which he thinks or hopes that he might be able to save 10 per cent. in coal consumption. He will tell the manager that he will positively be able to cut down the cost of fuel at least $4000 per year if he is permitted to spend not more than $2000 for an equipment of scientific instruments necessary to do it.

The manager immediately figures that a minimum saving of $4000 with a maximum investment of $2000

represents a yield of 200 per cent. on the investment, and that is impressive. There is nothing that will ease up the purse strings so effectively as the certain prospect of a large dividend on a moderate investment. If the engineer is sufficiently fortified by practical and theoretical knowledge, the chances are ten to one that he will get what he wants, and a hundred to one that he will make good after he gets it. For small plants the investment is proportionately less, but the percentage of saving is relatively larger because small plants are generally less economically operated.

The question of fuel economy is of the most vital importance to the engineers in charge of the so-called isolated power plants. These plants produce no salable goods. Their product is power, light and heat, generally for home consumption only. In these plants the cost of coal is generally over 50 per cent. of the total operating cost. The importance of fuel economy is therefore ten times as great as in the average manufacturing plant. While isolated plants do not compete with one another, they all have a powerful competitor in the central power station. The agents of the central station are on the alert to discover uneconomically operated power plants and are putting out of business many that are slovenly and wastefully managed.

Operating Engineer Must Take Initiative

It is up to the operating engineer to keep his plant in first-class running order. He must take the initiative in obtaining an equipment of necessary scientific instruments to enable him to run it with maximum efficiency and economy, not only as a matter of reputation—although that alone should be sufficient incentive—but because his very bread and butter are at stake; for as surely as night follows day, the isolated plant that cannot compete with the central power station will go to the scrap heap, notwithstanding the fact that a properly equipped and economically operated isolated plant can supply light, heat and power at a lower figure than central-station managers are inclined to quote.

Every competent engineer thoroughly understands the mechanical end of his profession and knows how to make and maintain the proper adjustments of engines, auxiliaries and all other machinery that properly comes under his care; but not one in ten is thoroughly familiar with the chemical reactions that constitute the process of combustion or has studied out the fundamental principles on which combustion efficiency depends. Without a knowledge of these principles the operation of a boiler is little more than guesswork.

Adjustments Must be Continually Altered to Meet the Varying Conditions

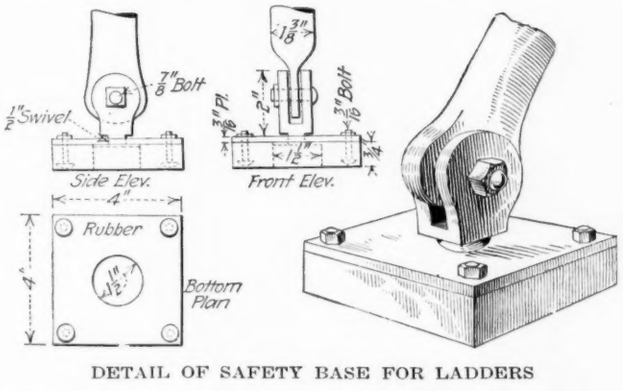
The boiler differs from every other machine or apparatus in a power plant in that permanent adjustments are not permissible. To get the best results the adjustments must be continually altered to meet the changing conditions, such as variable steam demand, changing condition of fire bed, variation in the quality of coal, variation in the direction and velocity of the wind and of barometric pressure, etc. The draft must be adjusted to meet the varying steam demand, and the thickness of fire must be regulated to the draft. If the draft is too strong for the thickness of the fire, heat is wasted through undue excess of air; and if the fire is too thick for the draft, fuel is wasted through incomplete combustion.

Every engineer knows these facts, and he depends on his fireman to make the necessary adjustments. The steam gage tells the fireman when to fire harder and when more moderately; but if he has nothing to tell him whether his adjustment of fire to draft is right, he will burn coal more or less wastefully. As the engineer is the responsible person, he should see to it that the fireman is provided with the instruments necessary to enable him to make these adjustments intelligently and correctly. The engineer must also provide himself with instruments that will autographically record the performance of his firemen and his boilers. Without the aid of such records he can have no positive control over either.

Fuel is becoming more expensive from year to year, and at present its economical use is a vital question. It is therefore up to the operating engineer to burn his coal efficiently. To solve the problem of how maximum efficiency can be secured, the engineer must have a thorough understanding of the process of combustion and he must know what instruments are necessary to diagnose and control combustion. He must familiarize himself with all the instruments available, and for this purpose he must study their individual functions, so as to be able to discriminate between those more or less useful and desirable and those necessary, and to choose the best of the latter.

Safety Base for Ladders

A satisfactory safety base for a ladder that is to be used on cement or iron floors may be constructed from old and soft rubber pump valves or disks, says W. H. MacMahon in *Engineering and Mining Journal*. These disks are 5 in. in diameter and $\frac{3}{4}$ in. thick, with a $\frac{3}{4}$-in. circular hole in the center. In making the base, the



DETAIL OF SAFETY BASE FOR LADDERS

hole is enlarged to $1\frac{1}{2}$ in. and the disk fastened to a piece of iron plate by means of four small bolts whose heads are countersunk in the rubber. The plate, with its rubber face, is fastened to the ladder by means of a swivel joint. The sketch shows the details of construction. The rubber disk has been trimmed to 4 in. square to make a neater looking job, although the base works just as well when the full-sized disk is used. The swivel joint is made as tight as possible, so that the cavity in the rubber will act as a vacuum cup and will hold securely on wet floors.

The Rate of Combustion

In Illinois this is the week to study the rate of burning coal. The full week is to be devoted to the subject, and its importance as a factor influencing economy would warrant giving it continuous attention. The fourth weekly letter issued by Joseph Harrington, administrative engineer, is a concise treatment giving valuable information on this topic. The letter follows verbatim:

The rate of combustion per unit area of grate surface has a very great effect on the efficiency of the furnace. Boiler tests will bring out the facts that each combination of boiler and furnace has a point where it is most economical and this point is affected more by the rate of combustion than by the boiler itself.

To secure high efficiency, therefore, there must be an amount of coal burned per square foot of grate surface per hour that will permit of the most complete burning of the fuel with the least amount of ashpit loss or excess air.

In the State of Illinois, where chain grates are to be found in abundance, the conditions are substantially as follows: Chain-grate coal is usually classed as screenings or nut and slack. Generally speaking, coal that passes through screens having 2-in. round holes, is the coal classified as above and usually purchased for chain-grate use. This coal will have anywhere from 20 to 40 per cent. nut in it over half-inch size.

Reference to the draft gage connected to the furnace will show that in the great majority of installations there is a draft equal to 0.1 to 0.3 in. of water with an average probably around 0.2 inch. With modern settings, where the value of adequate draft was appreciated by the plant designer, higher stacks exist and the average furnace draft is usually nearer 0.3 inch. With this type of stoker it is possible to burn between 25 and 35 lb. of coal per square foot of grate surface per hour. A rule which holds fairly well is that you can burn 10 lb. of coal per square foot of grate surface per hour for each 0.1 in. draft in the furnace. This holds very closely with a combustion rate between 20 and 35 lb. per square foot of grate surface.

Under these conditions, as will be explained in greater detail in a subsequent letter on gas analysis, 12 per cent. of CO_2 at the boiler damper is about the maximum desired. Assuming that this is the ideal condition, it will be found that the rate of combustion has a very marked effect thereon. For the proper burning of coal, a fairly high temperature in the furnace is desirable, but it cannot be obtained unless there is a brisk fire and consequent generation of heat at a rapid rate.

When the rate of fuel consumption per square foot on the chain-grate stoker drops below 12 to 15 lb. per sq. ft., it is more than likely that there is a large loss of combustible. The first loss will be due to unburned carbon in the ashpit and the second loss will be due to unburned hydrocarbons in the stack gases. Another loss, which could properly be included, would be the excess air which could enter the furnace through the rear or thin portion of the fuel bed. This latter frequently occurs in conjunction with the second, especially in those types of furnace where the mixing effect is deficient.

There is under these circumstances very sluggish combustion and the fuel is inclined to burn out unevenly. The stoker is operated at a low rate and the fuel remains on the grate surface a long time. Holes will develop or the rear of the fire will become very thin. If the stoker is operated fast enough to carry the fire back to the rear of the grate, loss in the ashpit is almost unavoidable. Under these conditions, careful attention should be paid to the damper in order to adjust as nearly as possible the draft and the rate of stoker feed to the rating desired. Where more than one boiler is in service under these conditions of low capacity, it is usually found more economical to bank one boiler and carry the entire load on the other, obtaining from it the maximum efficiency.

Considering the other extreme of high rating, it is a fact that the efficiency of the boiler and stoker drops off very rapidly after a certain point is reached. This point is reached when the maximum draft is applied and no more coal can be completely burned. With many installations, this is reached when about 35 lb. of coal per square foot of grate is consumed. Any attempt to feed more coal under these conditions would simply result in burning off the combustible volatiles before dumping most of the fixed carbon into the ashpit. This involves heavy waste and if this condition persists for more than a short time another boiler should be put into service.

Much of the foregoing applies equally to hand-fired furnaces, only the rate of combustion practical to develop is somewhat less. Assuming the same general kind of fuel, hand firing usually reaches its maximum at 25 to 30 lb. per square foot, and unless draft conditions are excellent 25 lb. will be the limit. The maximum is somewhat less than in the case of the chain grate owing to the difference in the character of the fuel bed and the difficulty of filling the holes in the fire as they develop. It is, however, considered possible, if proper care is used in keeping the fire even, to burn as low as 10 lb. of coal per square foot per hour with reasonable economy.

Inasmuch as other stokers of natural draft type follow along the general lines of the chain-grate stoker, so far as rates of combustion are concerned, they will not be mentioned here in detail. The underfeed type of stoker is in a separate class on account of the use of artificial draft. It is felt that in Illinois the hand-fired plant will include the large majority of all installations.

During the week devoted to the study of this matter, and especially in hand-fired plants, I urge you to make an analysis of this situation by finding out the total amount of active grate surface under each boiler and weighing the coal to each boiler for a period of not less than one day. Keep a careful record of the furnace draft and of the coal weighed to each boiler by hours so that you can plot a curve for each boiler showing the coal consumed each and every hour on the basis of pounds of coal per square foot of grate. See how closely this comes to the general principles laid down in the preceding. Make this a matter of record in the boiler-room log for future reference.

EDITORIALS

Fast Colors in Patriotism

REAL patriotism is not a costume for parades, to be put away in mothballs after the shouting and the tumult have ended. Neither is it a chameleon cloak that will change its hue to conform with every alteration of surroundings and conditions. Its color—if it can be said to have color—must neither run nor fade. It must be permanent or it is valueless.

Neglecting the small percentage of alien sympathizers and pro-German apologists, the people of the United States have shown evidences of splendid patriotism during the war now so happily ended. Government control of private enterprise, price fixing, restrictions on freedom of speech and action, censorship of the press, regulation of food supply and fuel distribution—these and dozens of other things were borne willingly and uncomplainingly by all classes because they were deemed essential to national welfare and success.

The termination of active hostilities alters the situation. The coming of the period of peace ushers in a new set of circumstances. The necessity for the continuance of many war measures disappears entirely, but in their stead rise new problems and new responsibilities that must be faced and solved.

We are not out of the woods yet, nor shall we be for months to come. There will be further loans for popular subscription, new issues of War Savings Stamps to be bought, additional taxes to be paid and fresh appeals for works of charity and mercy to be met. There will be millions of soldiers to be reinstated in the industrial world without injustice to those who remained at home and labored untiringly for the success of our armies abroad. There will be need of a satisfactory adjustment of the recurring differences between employer and employed.

Herein will lie the supreme test of our patriotism. During the war period, when the hearts of men were stirred by the martial spirit and the swift, sure progress toward victory, it was easy to labor and sacrifice for the good of the nation. But in the calm of peace times, lacking the thrill of war news and the excitement of the conflict, the real spirit of our people will be put to trial and will be judged by the patience and vigor with which they attack the complex and vexing problems of reorganization and reconstruction.

It is a task that will require the best that is in us and its magnitude is not underestimated. But surely the people from which sprang the army that stood like a rock at Chateau-Thierry and broke into scattered spray the furious wave of Prussianism, that reacted with a mighty blow which echoed around the world, that flattened into impuissance the menacing salient at Saint-Mihiel, that crept undaunted through the Hun-infested Argonne and swept it clear of the foe, that plowed its way irresistibly through one line after another of carefully prepared and strongly held German defenses—surely such people as these will not now suffer themselves to grow lukewarm in their devotion to their country or in their passion to serve her.

This is no time for heckling or hysterics. It is a time that demands cool heads, clear foresight and sound judgment. In short, it is a time for the exercise of that spirit which not only prompts a man to offer his life for his country but makes him infinitely more willing to live and work for her.

Will the Saving Continue?

FUEL Administrator Garfield estimates that three and a half million tons of coal has been saved in the last six months by plants that have adopted the conservation recommendations of the Fuel Administration. This indicates that those in charge of steam power plants had not been properly performing their duties. It means that at the same rate of consumption some thirty-five million tons of coal was needlessly burned during the last ten years, having a value of one hundred and forty million dollars, assuming that the coal cost the low price of four dollars per ton. It is estimated that the average saving in such plants as have adopted conservation methods has been twelve per cent.

The strange part of this is that the opportunity for saving in these plants existed long before the Fuel Administration came into existence, but was not taken advantage of. Engineers knew that certain conditions were responsible for coal waste. They knew that if these conditions were rectified, less fuel would be burned and that the operating expenses of the plant would be decreased. However, with this knowledge in hand nothing was done in many plants to prevent this fuel loss.

What was the reason? Why did not the men in charge of steam plants give this problem of coal saving more consideration? Why was it necessary for the Fuel Administration to recommend various changes before they were made?

Doubtless there are several reasons. One probably is that in some of the steam plants, at least, those in charge were indifferent as to whether fuel was saved. This is easily accounted for by assuming that the conditions found by representatives of the Fuel Administration had existed for years, and that the engineer in charge had gotten into a rut, taking it for granted that matters were going along satisfactorily from every point of view. The chances are that there were no instruments in the plant to permit of determining what results were being obtained. If this was the case, the engineer had no means of knowing what his losses were, when they were occurring, or what to do to better conditions.

Another reason may have been that, although the engineer was aware that fuel losses were occurring, he was unable to get his employer interested. This is not an uncommon state of affairs, and under such the fault of fuel waste lies with the owners. No matter how enthusiastic an engineer may be regarding the economical

operation of his plant, no owner can expect that he will spend his own money in order that a saving in the operation may be made.

Success in most enterprises depends largely upon the coöperation of all concerned. If a power plant is blessed with an engineer who knows his business and attends to it, and is owned by men who will provide suitable instruments and apparatus, there is every reason to expect that good results will be obtained, and it is safe to say that where these conditions existed the Fuel Administration found little opportunity to suggest improvements in the method of operation.

Several years ago an editorial in *Power* brought out the fact that although the electrical end of power generation was equipped with all desirable and necessary instruments for controlling, measuring and recording the electrical output of a plant, the steam end was usually obliged to get along with a gage-glass and column, a steam gage and a safety valve, and no more. Limiting a boiler room to these three pieces of equipment is putting a handicap on its performance that will defeat the most energetic endeavors of an engineer. To be sure, practically all up-to-date power plants of large size have some if not all of the apparatus necessary to enable the engineer to determine when he is getting the best out of his equipment, but there are thousands of smaller plants that are equipped with only the three pieces of apparatus, and even these are not always in shape to function.

Of course some of the firms that have reaped the benefits of fuel saving will continue to maintain the standard obtained, but what of the majority? Will the control of a large percentage of these plants become lax when the war is over and the price of coal drops, and go back to old conditions? We believe not. It is possible for one to continue certain methods year after year, believing that they are good and efficient, only to find when forced to make a change that different practices are better. Every progressive engineer will maintain the standard that he has obtained under pressure, if it may be so called, and it is safe to predict that he who allows his plant to deteriorate to its former condition will find another engineer standing at the door to take his place.

Automatic Record of a Boiler Explosion

A BOILER which exploded at Detroit recently had a pressure regulator attached, and the chart reproduced on page 776 indicates that the rupture took place at about forty pounds. The release of the pressure at about 7:10 a. m. is clearly shown, but the diagram is complicated by the line indicating an abrupt rise of pressure somewhat later to one hundred and twenty pounds, as well as by an extension of the diagram at the base of this line to the 8:30 a.m. radius. There is little doubt that the abrupt rise at *B* as well as the hook at its base were made by bungling manipulation in the removal of the chart. The time of the explosion is given as ten minutes of eight, but the abrupt drop of pressure occurs at about ten minutes past seven, which, if the observed time is correct, suggests that the chart was put on wrong. The instantaneous increase of pressure to one hundred and twenty pounds, however, indicated by the presumably accidental line upon the chart occurs, if the chart is right, at the observed time of the failure, and this line will give rise to speculation as to the possible generation of such pressure by pumping water into an overheated boiler.

The instance emphasizes the importance of neatness and precision in handling recording apparatus of this sort. Hundreds of diagrams may be made and destroyed without having any particular significance and then, as in this case, a day may come when the story told by the diagram is of extreme interest and importance and should be open to no kind of question.

In Philadelphia, during a recent shortage of electric power owing to an accident to a large turbo-generator, someone cited the Merchant Shipbuilding plant at Bristol as having a surplus of some three thousand kilowatts. Is it not probable that there are numerous other instances where some plants are working at peak loads while there are others that are operated at only part capacity and could be connected to the overloaded station? Investigation would do no harm and perhaps disclose a way out of some of the power-plant overload difficulties.

The Government has bought a mass of material, including power-plant apparatus, for which it will probably have no use. Stories are already afloat of the unloading of tools and machinery at a fraction of the purchase price. No doubt much of this material will have to be disposed of at a serious sacrifice, and power-plant owners and engineers should be given an opportunity to bid upon it.

Ultra refinement in the operation of the boiler plant, while a steam trap is blowing through "way yonder" at the end of the line, does not fulfill the conditions of even reasonable plant efficiency. In other words, no boiler plant is efficient enough to permit of its product, steam, being wasted.

We did not realize how sensitive coal production was to health conditions, politics and the spirit of playfulness. The output which exceeded 15,000,000 net tons for the week ending September 28 has fallen off steadily ever since, due, it is said, to the influenza, election and peace celebrations.

The indicator contest ends with this month. Send in an account of the most meritorious use that you have made of the instrument and it may win an indicator or planimeter according to the offer on page 205 of our issue of August 6. All entries must be in by November 30.

The ending of the war will make no difference in the activities of the Shipping Board. Engineers and firemen are still needed for the new merchant marine, and men between eighteen and thirty-five will still be accepted for training.

The emergency power bill passed by the House appropriating $150,000,000 to provide power for war industries will probably "die a borning." Unless something unexpected breaks out, we shall not need the money.

CORRESPONDENCE

In these and other columns "Power" wants to tell how you have decreased the fuel consumption in your plant. Since the fuel shortage, engineers have been thinking hard about conserving fuel. Thousands have made changes in equipment, in operating methods, and in modifications to boiler settings, etc., all of which have, in many plants, greatly cut fuel consumption. You owe it to the country to tell your fellow-engineers how you have saved coal. "Power" will pay for good articles that will help the other fellow save coal as you have saved it. Engineers must save at least 35 million tons this year. Let's have your story.

Cast Brass Valve Seats Porous

In a plant of which I once took charge, I found that the blowoff valves were giving a lot of trouble. The original disks had been discarded for some reason and new brass ones, cast in the plant, had been substituted. I had several new ones faced up and tested them with city water pressure and found that only one out of five was fit to use; the others leaked badly because the casting was spongy or porous.

Not having time to get new ones cast and not knowing whether they would be any better, I had a coat of solder applied to the backs of the disks, which made them perfectly tight R. McLAREN.

St. Catharines, Ont., Canada.

The Boiler-Room Scales

With the desire of being helpful and constructive in criticism, I should like to comment on the frontispiece in the issue for Oct. 29, which shows an industrial plant with two men in the foreground discussing plans for saving fuel. A conspicuous feature is the reproduction of a chart from a recording draft gage, and on the sheet that the two men are examining are seen a flow meter, draft gage and a CO_2 recorder.

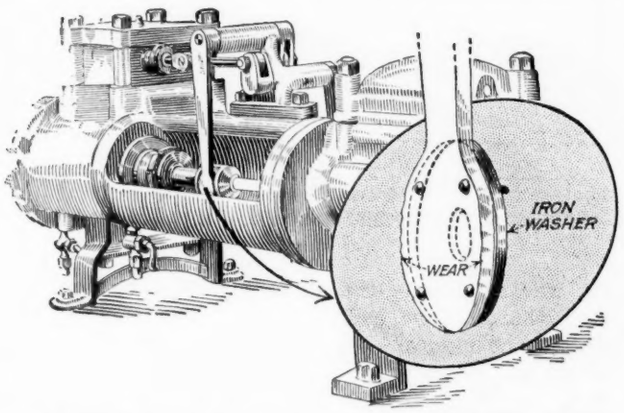
If we want to save money in our business, the first thing to do is to count it, and the fundamental way to save fuel is to learn exactly how much is being burned. With nothing but the highest respect for the auxiliaries indicated in the cartoon, I submit that the most important thing in a boiler plant, tending to save the fuel, is a good scale for weighing the coal. The efficiency and economy of a station is expressed in pounds of water evaporated per pound of coal or pounds of coal per kilowatt-hour, and the essence of the determination is the weight of coal. There is no use in pounding the chief to use less coal, unless he is given something to go by. His men can't tell how much they are burning unless they have good scales, and all the boiler-room auxiliaries in the world are secondary to the weight of fuel burned.

When the weight of coal used by each individual boiler is available, a high consumption may well direct attention to a low CO_2 reading or a high reading on a pyrometer, the first indicating a faulty mixture of air in the furnace and the second probably indicating an accumulation of soot on the tubes, but let us have scales in the boiler room, as the first and most important fuel-saving device. B. K. HOUGH.

Boston, Mass.

Worn Pump-Valve Arm Repaired

Some time ago I had trouble with a hotwell pump. The long arm becoming worn at the spool allowed the arm to slip out of the spool, stopping the pump. We had no spare part so I made a quick and satisfactory



WASHER RIVETED ON WORN END OF PUMP ARM

repair by riveting a 1-in. washer on the end of the arm with four small rivets, as shown in the accompanying illustration.

I have had no more trouble with the arm slipping out of the spool, and the washer can be quickly replaced when it becomes worn. JOHN T. LOCKETT.

Trenton, N. J.

Rules for Hot-Water Heating Systems

In *Power* for Oct. 15, 1918, there appears on page 580, a short article, "Rules for Hot-Water Heating Systems." The directions given for saving coal are far from satisfactory. The article says: "All the water should be emptied from the plant and clean water put in at least as often as every spring and every autumn."

It is my belief that it is far better practice to allow the water in a hot-water heating system to remain in the boiler, pipes and radiators for many years. In my own hot-water heating system the water was left in for fifteen years. Nothing is to be gained by putting in new water and much scale will accumulate if the new water contains scale.

I suppose the author of the article means air-valve when he refers to the exhaust valve of each radiator, and he doubtless means expansion tank when he refers to the exhaust tank. L. P. BRECKENRIDGE.

New Haven, Conn.

Diagram Made After Eccentric Had Slipped

The two indicator diagrams shown are from the high-pressure side of a 20 and 34 x 48-in. Fulton cross-compound Corliss engine. No. 1 was taken when the engine showed that something was wrong and proved that the eccentric had slipped back about one-third

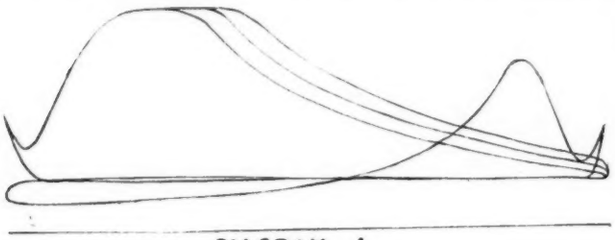


DIAGRAM 1

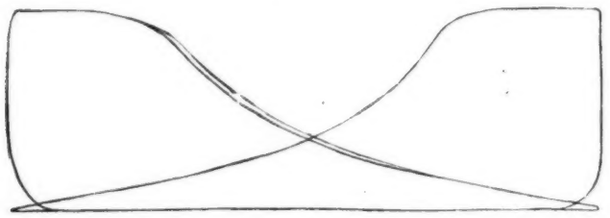


DIAGRAM 2

MISPLACED ECCENTRIC MADE NO. 1, READJUSTED IN NO. 2

the way around on the shaft, and No. 2 was taken after the eccentric had been put back in place with no other changes or adjustments. The engine operates at 100 r.p.m. with 160 lb. steam at the boilers. An 80-lb. spring was used in the indicator. There is nothing unusual about the diagrams but they may serve to help some brother engineer to locate his engine trouble. H. T. YUST.

Ottumwa, Iowa.

Different Water Level

I am reminded by the letter by R. D. Smith in the issue of Oct. 15, page 573, of a similar experience but with a different ending. I made periodical inspections of fourteen water-tube boilers in an electric power plant in my territory. One day a salesman came along with some kind of newly patented water column and persuaded the chief engineer to take one on trial. The boilers were all of the two-drum water-tube type, and rather than take down an old column the chief had the new column attached to a drum having no column; but when this boiler was put in service, he sent in a distress call for me to come to the plant. I hurried over to see what the trouble was, and the chief took me by the arm to the boiler room and showed me that there was a difference of five inches in the water level in the two drums of No. 6 boiler as shown by the two columns. I called up and verified the difference by means of a level. As he had plenty of boilers, the chief had No. 6 cut out again, and the next day he and I gave it a thorough internal inspection. There was no scale to speak of as the feed water was exceptionally good, and we examined the steam outlets to make sure they were all clear. Finding no trouble with the boiler, the difference in water level shown we laid to the new column, and in order to get proof we took one of the ordinary columns used on another boiler and attached it where the new one had been, filled and fired up the boiler and put it on the line only to have the two columns, which were exactly alike, show the same variation in level as was shown by the previous test. We took the boiler out of service and went over it thoroughly again, externally as well as internally, as we thought possibly the furnace conditions might have something to do with it, but we could not find the slightest difference between the two sides of the furnace or baffles. We then tried putting a column on each drum of several other boilers in the plant only to find that in every case a variation of from one to four or five inches would be indicated when the boiler was in service. We never found the trouble and gave it up as an unexplainable phenomena of steam generation. Can someone supply the answer?

New York City. C. S. REGAN.

Corrosion in Spare Boilers

The question by L. M. C. on the "Inquiries of General Interest" page (503) in the issue of Oct. 1, is one I was worrying over a few years ago. I partly overcame the trouble by lowering the water level during the period of idleness to a point just below the bottom of the gage-glass where the water line came on a part of the shell covered with scale that protected the plate.

When the boiler is "cut out" and the steam condenses, the boiler takes air (oxygen) through each leaking valve-stem packing and the like, and corrosion takes place along the water line. R. MANLY ORR.

Vancouver, B. C., Canada.

Lubricating the Cylinder of a Compressor

A 20 x 16-in. air compressor running at about 155 r.p.m. had been getting an unknown quantity of oil, but wishing to know how little would be enough, I adjusted the feed to barely two drops per minute and after running about a week inspected the cylinders, which I found to be thoroughly lubricated and in good condition. The gravity of the oil used was 27.3 Baumé.

That the compressor had previously been getting too much oil was evidenced by the fact that we recovered about ten gallons from the receiver. R. MCLAREN.

St. Catharines, Ont., Canada.

Shortening a Steel Beam Without Shears, Saw or Torch

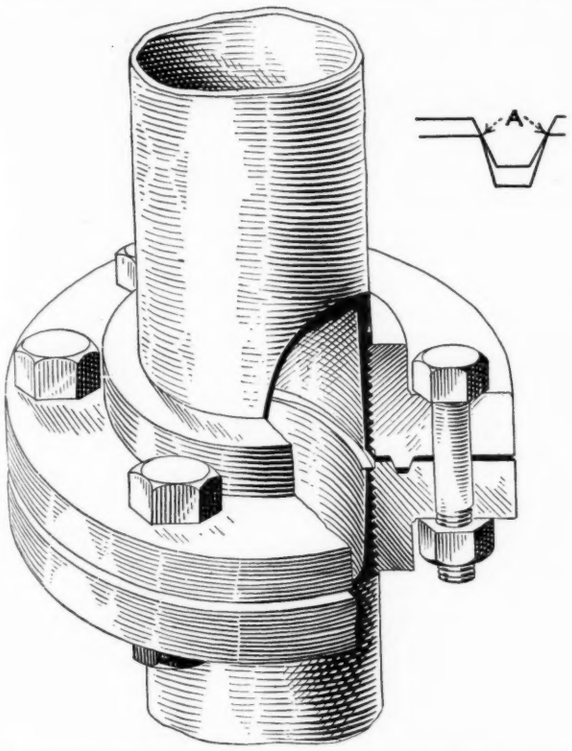
In doing construction work it is sometimes necessary to shorten (cut) an I-beam or other heavy section when no oxyacetylene torch or even a large enough hacksaw frame is at hand.

The job can be done by heating the beam, at the place marked, to a dull red and rubbing a stick of sulphur in it, all the way around, so the metal will absorb the sulphur and become "hot short." Allow the beam to cool, then tap it on the end with a sledge and it will break at the point where the sulphur was applied for the reason that the sulphur has made the metal brittle. ROY E. HANSON.

Clarkdale, Ariz.

A Metal-to-Metal Flange Joint

For over six months the soft packing between the flanges of a steam inlet to a fire pump on a tugboat kept blowing out and leaking. Grooves were cut over the surface of the flange and center-punch marks put all over the surface for the gasket to grip on, but nothing seemed of any use to prevent the packing from blowing.



SPECIAL PIPE FLANGE FOR A DIFFICULT PLACE

Finally, the flanges were taken out and turned, tongue and grooved, as shown in the illustration, so that a tight metal joint was made at points *A* in the enlarged view. The packing was eliminated and no more trouble from leaks was experienced. Would it not be advisable to apply this principle on all water or steam joints and eliminate packing? M. BERTRANDE.

Ozone Park, L. I.

Internal Feed Pipe Scaled Up

The scaling of the feed pipe inside the boiler as described by R. A. Williams, on page 643 in the issue of Oct. 29, is not an uncommon trouble. Some time ago I opened a return-tubular boiler and found over the tubes a pile of mud and scale about two inches deep and two feet in diameter, extending almost to the lower row of tubes. The feed pipe terminated above the tubes and had a tee on its end, which was also pretty well filled with scale.

I have found that a pan laid on the tubes into which the feed pipe extends will catch a great deal of the mud. The pan will have to be cleaned when the boiler is cleaned, but that is easier and better than having the scale on the tubes. The pan will also provide a seal for the end of the pipe and prevent water-hammer in the feed pipe. R. MCLAREN.

St. Catharines, Ont., Canada.

Not Properly Equipped To Use Exhaust Steam

The writer recently visited a plant using exhaust steam for dry-kiln heating, but in this particular plant, as in many others, the use of exhaust steam has resulted in uneven temperature and therefore poor kiln service. Utilizing exhaust steam for heating represents considerable saving, because a plant is thus enabled to make use of what would otherwise become a waste, but it was not the policy in this plant to turn live steam into the kilns except in cases of extreme necessity, and a further complication arose from the fact that the exhaust steam was used also to serve the bending retorts.

On one occasion, owing to forgetfulness on the part of the engineer, steam was not turned on after the plant shut down at noon Saturday, and there was no steam on until the following Monday morning. In this case the engineer was working under some disadvantage, due to the fact that his engine was overloaded a great deal. The plant was equipped with an oil separator, back-pressure valve and pressure-reducing valve, but it was out of order. The back-pressure valve was set at 8 lb., and when the engine was running under heavy load, there was often enough exhaust to produce this pressure. At other times, when the engine was running light, the pressure would drop as low as 2 lb. or less. The reducing valve being out of order allowed the pressure to drop and it was necessary to turn the live steam on by hand. Frequently, the engineer would not notice the drop and would fail to turn on the live steam at once.

It is not nearly so important at what pressure exhaust steam is supplied to a kiln as that this pressure be maintained without great variation. It is manifestly impossible to maintain even temperature when the steam pressures vary from 0 to 8 lb., and it is also impossible to secure good drainage under such conditions. In every plant using exhaust steam for dry-kiln service the pressure should be kept uniform without depending on the engineer to do it manually. A nonreturn supply valve should be installed in the branch of the exhaust line supplying the kilns, and a pressure-reducing valve to make up any deficiency in the exhaust steam when it falls more than one pound below the predetermined pressure. LEE PRIOR.

York, Penn.

Second-Hand Engine in Bad Shape

Some time ago my employer bought a 100-kw. direct-connected reciprocating engine and generator set which was supposed to be in first-class condition. The set was shipped in a box-car and arrived in bad shape; the dynamo was badly smashed up, but the engine from outside appearance was in good condition. We had just got it on a foundation when the crankshaft of another 100-kw. set broke, so it was a case of hurry up and get the new set running as soon as possible. We got it ready late the following Sunday afternoon and tried it out with a light load, ready for Monday morning. It started off Monday morning in fine shape, and I was preparing to put the indicator on at noon, when the fireman came in and asked if that —— thing had any valves in it at all. He said he could not hold steam.

I took some indicator cards, and they looked just as good upside down as they did right-side up.

We got along as best we could until the next Sunday, then made an inspection of the valves and piston. The engine is of the balanced slide-valve (Watertown) type, the exhaust valves being operated by a separate eccentric. I found the steam valves in fair shape, but the exhaust valves surely had not been on their seats in a long time. I also found that there had been two rings on the piston at some time, but now there was one ring in two pieces in one groove and half a ring in the other groove. I had two new rings made in our own shop, and with two helpers we filed and scraped nearly all day at the exhaust valves and seats ready for another tryout Monday morning. The indicator showed that there was "some difference." I have had the valves out several times since and now the engine shows a good card.

This set had been running up to within a few weeks before we got it, and the engineer in charge had a license, but I think it must have been a "hunting license." I have often wondered how many more engines are being run in as bad a shape as this one was. Uncle Sam wants us to save coal—which we should and must do. But if there are many engines running with such "rat holes" in them, somebody may go short of coal.

Dansville, N. Y. JOSEPH GERBER.

Lubricating an Air Compressor

After reading in *Power* some time ago that water was good for helping to lubricate the cylinder of an air compressor, we decided to try it. We had just installed a compressor and were having considerable trouble with the valves carbonizing and getting hot.

We connected an oil pump to the air cylinder, filled it with water and fed a few drops of water per minute to the cylinder.

We have had no trouble with the valves carbonizing or getting hot since and it is a great saving in oil. The compressor works as well with one-third less oil.

Manassas, Va. R. A. WILLIAMS.

High Ash Content in Coal

The article by W. A. Shoudy in the issue of Nov. 5, page 682, entitled "Waste Due to Excessive Noncombustible in Coal" is interesting and timely and my experience in a plant having 33 boilers confirms his graphs. Within the last two years we have had coal that ran anywhere from 2.5 to 44 per cent. ash. We analyze a sample from every car of coal we get for noncombustible. Using railroad equipment to haul some of the stuff long distances was a shame.

When the ash runs above 10 per cent., the number of boilers required to keep up steam is about proportional to the percentage of ash. This is because when approximately that point is passed, the amount of coal we can burn is limited by the process of getting the ash through and away. In other words, the quantity of ash a given stoker will "get away with" without dumping an excessive amount of combustible is limited. The limit will vary with the character of the ash. So the capacity of a boiler or the amount of coal that a given stoker can burn with a reasonable degree of economy is about inversely proportional to the percentage of ash above 10 per cent., up to the point where difficulty begins to be experienced in getting it to ignite. We have some hand-fired boilers, some with stokers of the hand-cleaned type and some with stokers of the dump-plate type. The amount of ash per hour the hand-cleaned stokers will take care of is about 1½ times that which will give trouble with the hand-fired boilers, and the amount the dump-plate type will take care of is about three times that of the hand-fired boilers, due allowance being made for the difference in size of the boilers.

Midland, Mich. J. R. BELKNAP.

Governor "Safety" Was Tripped

That it is necessary for an engineer to be well acquainted with his engine in order to operate it successfully is illustrated by the following incident:

On starting up one morning the governor belt broke on the engine in a neighboring plant. The engineer laced the belt and put it on, but the engine would not start and he could not discover what the trouble was. He called up our plant for assistance just as I was going off watch, so I walked over to see if I could help him to get started. All the men were standing around waiting—and offering suggestions. I found that he had failed to reset the safety-stop device on the governor when he put the belt back on. This particular safety stop was of the type that has a pulley riding on the governor belt and attached to an arm that trips a spring that closes the governor valve in case the governor belt breaks. All that was necessary to get under way was to lift the governor-valve spindle and reset the trip. R. A. WILLIAMS.

Manassas, Va.

Orders To Test Subordinates

A chief engineer has a right to issue orders that will prove tests of the men under him. If they prove to be pure gold, they will profit by the tests, but if they are shown to be only imitation, the sooner it is demonstrated the better for all concerned. When a chief engineer applies to his subordinates tests which are reasonable and fair, but which may include unpleasant conditions, he is justified in treating them according to the results secured, and such action is not an evidence of a tyrannical or unfair disposition. Every living man is subordinate to somebody else, and when our superiors take interest enough in us to apply tests without notifying us of their intentions, we ought to be glad.

In a certain shop it had been customary to ring a fire alarm at irregular intervals in order to observe the effect of fire drills on the operatives. When a new superintendent took charge of the works, he sent notices to the heads of departments when he was going to ring a fire alarm in order that they might be ready for it. Could anything be more inefficient or ridiculous than this action? W. H. WAKEMAN.

New Haven, Conn.

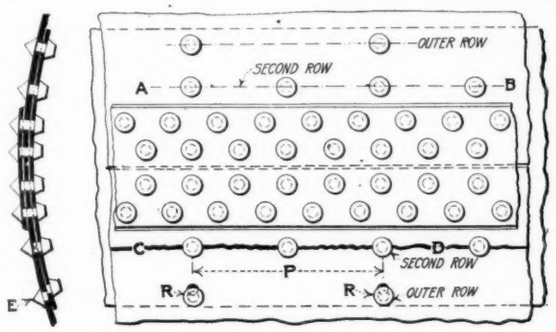
International development of electric power in the lower Niagara River is being urged. One plant contemplates the building of a dam near Lewiston, where it is estimated that two million horsepower can be developed. This, it is said, would not impair the beauty of the falls, but the impounded water would practically obliterate the rapids, and to some extent the whirlpool.

INQUIRIES OF GENERAL INTEREST

Avoiding Coal-Gas Trouble from Banked Fires—How can backing up of coal gas be prevented from banking of fires? S. J.

Burn off the volatile matter of the fuel until flame appears over the top of the fresh coal when the fire-door is opened. Then with the ashpit doors sealed with ashes and the fire-door nearly closed, adjust the stack-draft damper to sufficient opening to prevent escape of gas at the fire-door.

One Method of Failure of Quadruple-Riveted Joint—Referring to the solution of "Efficiency of Quadruple Riveted Joint," page 645, Oct. 29 issue of **Power**, what would be the appearance of fracture if the joint failed as a result of least strength from consideration (D); namely, "Strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row?" W. K. C.



A METHOD OF RIVETED JOINT FAILURE

The illustration shows a quadruple-riveted butt and double-strap joint with the main plate intact between the second row of rivets *AB*, in one side of the joint and fracture of the main plate between the second row of rivets *CD* of the other side, indicated by the irregular line *CD;* and shearing of the other row of rivets *RR*, also shown in sectional view at *E*.

Consideration (D) is based on the same conditions as those which would justify the assumption that if the rivets *RR* were left out, the whole stress pulling the joint apart would be taxed on the tensile strength of the main plate between the rivet holes of the second row *CD;* and conversely, if the main plate were to be cut through from rivet hole to rivet hole of the second row *CD*, the whole stress pulling the joint apart would be exerted against the shearing resistance of the rivets *RR*, of course assuming also that the inside strap is capable of holding the rivets to their work and of transmitting the shearing stress to which the rivets of the second row are subjected.

Pinholes in Galvanized Water-Pipe Line—Does galvanizing decrease the durability of underground water-pipe? A 1¼ in. pipe line that has been down for about five years shows leakage through pinholes which have rusted through the sections that were laid of galvanized pipe, while the portions of the line that consist of black pipe appear to be in good condition. B. R.

Where the galvanizing is well done and impurities of the water are not especially destructive to zinc, the process of galvanizing increases the durability. But where the coating has been carelessly performed, there will be spots left uncovered by the zinc. At such places deterioration takes place more rapidly than in all-black iron pipe and probably for the reason that there is galvanic action due to the difference in the rate of corrosion of the metals.

Required Size of Pump Plunger—A direct-acting steam pump is required to work against a pressure of 145 lb. per sq.in. gage. The suction lift is 16 ft. If the steam pressure is 130 lb. gage and the steam cylinder of the pump is 8 in. diameter, what diameter of pump plunger would be required, assuming the friction loss from all causes to be 40 per cent.? J. E. N.

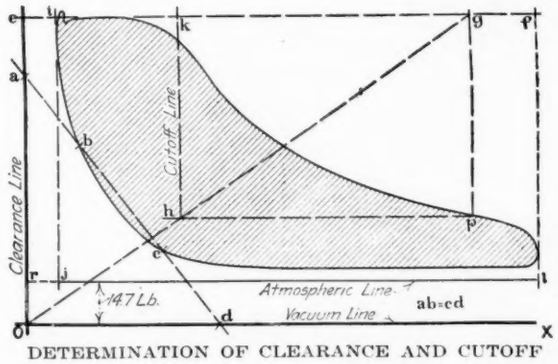
The piston of the 8-in. diameter steam cylinder would have an area of $8 \times 8 \times 0.7854 = 50.265$ sq.in., and allowing back pressure 2 lb. gage, the effective pressure moving the piston would be $130 - 2 = 128$ lb. per sq.in., exerting a total force of $50.265 \times 128 = 6433.9$ lb.; but with friction losses amounting to 40 per cent., the force available for overcoming the pressure pumped against would be $6433.9 \times 0.60 = 3860.3$ pounds.

A suction lift of 16 ft. would reduce the suction pressure $16 \times 0.433 = 6.9$ lb. per sq.in., and the net pressure to be overcome per sq.in. of plunger would be $(14.7 + 145) - (14.7 - 6.9) = 151.9$ lb. per sq.in.; and as the total force available would be 3860.3 lb., the plunger area would need to be no larger than $3860.3 \div 151.9 = 25.4$ sq.in., which corresponds to a diameter of $\sqrt{\frac{25.4}{0.7854}}$ or about $5\frac{11}{16}$ inch.

Percentage of Clearance and Cutoff from Indicator Diagram—How are the percentages of cylinder clearance and of cutoff determined from an indicator diagram? B. H.

The figure illustrates the method of determining the cylinder-clearance volume from the compression line of the diagram and the theoretical point of cutoff based upon a point in the expansion line.

Locate the vacuum line *OX* parallel to the atmospheric line and 14.7 lb. below it, according to the scale of the diagram. Draw a straight line *abcd* across the compression curve cutting *OX* at *d* and then from *b* lay off *ab* = *cd*. Through *a* draw *aO* perpendicular to *OX* and this will be the clearance line. Draw *ij* and *lf* tangent to the ends of the diagram and perpendicular to the atmospheric line.



DETERMINATION OF CLEARANCE AND CUTOFF

Assuming that *jl* represents the volume displaced by the piston, and *ei* or *rj* the clearance volume, the percentage of clearance would be, distance *rj* × 100 ÷ distance *jl*. To find the theoretical percentage of cutoff, first draw *ef* parallel to the atmospheric line to represent the initial pressure, and selecting any point *p* in the expansion curve, preferably near the point of release, erect the perpendicular *pg*. Draw a diagonal from *g* to *O* and from *p* draw *ph* parallel to the atmospheric line, and from the point of intersection of *ph* and *gO* draw the vertical line *hk*. This will be the cutoff line and the theoretical point of cutoff for the assumed initial pressure and point *p* will be at *k;* and the percentage of cutoff will be, distance *ik* × 100 ÷ distance *jl*.

Injuries Caused By Slippery Floors

By Chesla C. Sherlock

Slippery floors are a fruitful source of injury as is generally well known, and in employments where grease or oil is allowed to fall on the floor while being used on machinery, the hazard is greatly increased. There is no condition of a floor that can be worse from the standpoint of probable accident than a floor covered with oil and grease.

Its character should be so apparent, so noticeable to all, as to seemingly amount to negligence per se, but upon this point there seems to be no judicial expression. The courts have, however, had to visit liability upon employers in a number of instances for maintaining floors in a condition so as to be responsible for resulting injuries to employees.

In an Indiana case, decided in 1913, the plaintiff was injured by slipping upon a slippery floor and coming in contact with the uninsulated terminals of a motor used to operate a saw. The plaintiff alleged that the binding posts of the electric motor or dynamo were uninsulated and unguarded, and that the floor was maintained in a wet, greasy and slippery condition at the place where he had been required to work.

It was shown that the decedent knew of the slippery condition of the floor, having worked at the place for more than three months prior to the accident, but that he did not know of the uninsulated terminals. The injury was, of course, caused by the uninsulated character of the terminals, but the proximate cause thereof was the slippery floor as he would never have come in contact with the dangerous electric current if he had not slipped upon the damp, greasy floor. The court, however, was of the opinion that the verdict should be for the employee. Said the court:

These facts show conclusively that he did know, or should have known, of the dangerous condition of the floor and that he assumed the risk of all injuries of which the slippery floor was the sole proximate cause. If the only injuries received by decedent were such as were occasioned solely by the fall, he could not have recovered; but if his death resulted proximately from another cause for which the negligence of the defendant was responsible, he cannot be deemed to have assumed the risk of injury resulting from such cause, unless he knew of the danger to which this particular negligence of the master exposed him.

The court then went on to say that there were two conditions rendering the working place unsafe, both of which were due to negligence of the defendant and that both of these conditions concurred in producing the decedent's death and were the combined proximate cause. The court did not believe that the slippery floor was the sole proximate cause, as was found by the trial court, and found for the plaintiff upon this basis.

Oil and grease on the floor of the engine room form a fruitful source of injury, as they do when found near any revolving machinery.

Texas Supreme Court Ruling

In a Texas case the plaintiff's intestate was employed as a stationary engineer in the defendant's cotton mill. The injuries causing death were brought about by the decedent slipping on a greasy floor and falling against the revolving flywheel of the engine. It was shown that the engine was set on a cement base which was several inches wider on the side than the engine frame, and about six inches higher than the surrounding floor of the room. In order to reach and oil the eccentric on the engine, it was necessary for the engineer to stand on this extended space of the cement base upon which the engine rested.

A shaft carried a large driving wheel, the space between the engine and the wheel being used as a passageway for performing various duties about the machine. The wheel revolved partly above and partly below the engine-room floor, and an opening was made which was about fourteen inches on the side of the wheel and was safeguarded by an iron rail about four feet high, running across the middle.

The petition alleged that the decedent, "acting prudently and in the performance of his duty, went between the engine and driving wheel and the pit, and his feet slipped under him on the broken, uneven and greasy floor and he was precipitated into the unprotected pit around said wheel, or he stepped into said pit while at his work, or otherwise came into contact with said unprotected wheel when said wheel was revolving with much rapidity and force, and, his clothes and limbs becoming entangled in said wheel, he was instantly torn and mutilated and killed."

The supreme court refused to allow the plaintiff to recover, stating that the foregoing allegations were indefinite as to what the plaintiff relied upon for a recovery; that whatever caused or contributed to the decedent's death was obvious to the decedent as he was an experienced engineer and had been oiling the machinery himself, and since there was nothing to show that the oil could have been spilled on the floor by anyone else, the inference was that he had spilled it there himself. With the knowledge of the defects and the dangers involved, the decedent must be held to have assumed the risk of injury from such causes.

Decision Rendered by Wisconsin Court

In a Wisconsin case a carpenter was employed to remove a revolving fan from the engine room of a garage company. In reaching the engine room it was necessary for him to go through the garage room. To reach the fan it was necessary for him to use a ladder, and after getting on the ladder he slipped and stuck his hand into the fan with the result that he lost three fingers. At the hospital he found grease upon the soles of his shoes, and he contended that it was the grease on the floor of the engine room, which had become attached to his shoes, that had caused him to slip and receive the injuries complained of.

The engine room was in the basement, was poorly lighted and the plaintiff had never been there before. He did not know the conditions existing there, but had a right to assume that it was a safe place to work.

The court pointed out the fact that garage floors are always more or less oily and greasy from the constant working with cars and that this fact is known to all or could be ascertained as soon as one enters such a place. The plaintiff had crossed the garage floor both in going to the engine room and in leaving it for the hospital. The court said that there was a possibility that the grease became attached to the plaintiff's shoes in the garage, but that even if conceded that the grease became attached to the plaintiff's shoe on the engine-room floor, there was nothing to show that it was there a sufficient length of time to constitute negligence in not having it removed. The burden of proof was upon the plaintiff to show to a reasonable certainty that defendant was negligent and that such negligence was the proximate cause of the injury.

It is not sufficient to show two or more causes, some of which are actionable and some of which are not, and from such evidence permit the jury to guess or speculate as to which one of the two occasioned the injury.

Oil and grease upon the floor are not, of course, the only substances which will render a floor slippery and dangerous to the workman. Water may achieve the same result, while ice is a common source of danger during the winter months. What has been said in the cases cited relating to oil and grease will apply in equal force to other situations in which the floor had become slippery from other causes.

If the floor has been in a slippery condition for any length of time and the injured party has known this or ought to have known it, then he will, in the common-law jurisdictions, be held to have assumed the risk, unless he reported the condition to his employer and refused to work unless it was rendered safe.

In the states where the doctrine of assumption of risk has been abolished by the workmen's compensation acts and other legislation, the manner of the injury or the proximate cause thereof would be of small consequence, provided the injury arose out of and in the course of the employment, in which case the employer would be liable for the payment of compensation.

It is so easy to eliminate this class of injuries entirely that employers are to be severely censured for not exercising the greatest care to prevent them. Sand or sawdust on the floor is effective.

Military Problems Awaiting Improvement

The Inventions Section of the General Staff of the United States Army has submitted the following problems requiring scientific and inventive talent for solution, and requests that the engineers of America give them serious thought and consideration. Ideas and suggestions should be submitted to: Inventions Section, General Staff, Army War College, Washington, D. C.

Problem No. 1. Liaison Problem—In operations of our troops fighting in France, all have seen the necessity of perfecting liaison between elements of the front-line troops and between front-line troops and elements further to the rear. Liaison between the infantry is now maintained by sending forward with the infantry a large artillery liaison personnel, well equipped with the material of liaison—telephones, wire, flags, projectors, rockets, radio, etc. The War Department is desirous of finding a new means of communication whereby closer liaison may be maintained by the different elements of a command.

A device for this purpose should be small and compact, without antennæ exposed to shell fragments; it should be easily transported by one man, or at the most by three men; it should be capable of being set up quickly, and not present a target to the enemy; it should operate over a distance of at least five miles and be certain of action.

Problem No. 2. An Aviation Problem—On night bombing expeditions and even in the daytime, when passing through fog or clouds, an airplane is guided by a compass; but, unfortunately, when placed where the aviator can see it, it is directly between him and the engine, a position which greatly affects its accuracy. What is needed is some device or arrangement whereby a compass can be mounted far enough away from the engine to be outside of its magnetic influence and still be so arranged that it can be easily read by the aviator.

Problem No. 3. A Better Fire-Control Gear for Fixed Machine Guns on Airplanes—The function of a fire-control gear is to control the fire of an aircraft machine gun shooting through the propeller so that no shots will be fired when the blades of the propeller are in a position where they are in danger of being struck. The ideal fire-control gear should have the following features:

1. Maximum rate of fire is obtained at all r.p.m. of the propeller.
2. The time of impulse is advanced as the propeller speed increases, so that shots at maximum speed will fall in the same position with reference to the blades of the propeller at the plane of the propeller as shots at zero speed.
3. Easily placed at any position with reference to the engine.
4. Simple to take care of and adjust.

It is obvious that if the first advantage is obtained, the second must be sacrificed, but a better combination of the two is desired than that which we have at the present.

The problem which presents itself is to devise a fire-control gear which incorporates the above advantages. The solution seems to lie in an electrical system.

Calculations must be based on the following data:

Distance from muzzle of gun to plane of propeller varies from 3 to 6 feet.

Maximum propeller speed, 1600 r.p.m.

Rate of fire of airplane machine gun, 1200 shots per minute.

Problem No. 4. New Rear Sight for the United States Rifle, Caliber 30, Model of 1917—It is desired that designs be submitted for a new rear sight for the United States rifle, caliber 30, model of 1917. The present rear sight is not regarded as entirely satisfactory, wholly because the rifleman cannot readily bring the point of impact of the shots to coincide with the point of aim. The present sight can be adjusted only for hundreds of yards of elevation, it not being possible, for example, to adjust it between 400 and 500 yd.; also, there is no lateral or windage adjustment.

It is strongly desired that this new rear sight be capable of being placed on the present receiver of the Model 1917 rifle without any modification of the receiver whatever.

No rear sight the cost of which is not prohibitive, and which retains the present desired principle of aiming (a large aperture in a small disk), has yet been presented.

Problem No. 5. Pyrotechnic Smoke Signals—It is desired to secure, if possible, a suitable chemical substitute for red saxony arsenic now used for the manufacture of yellow smoke signals. The characteristics of such a chemical are that it should produce the effect required, that it should be procurable in large quantities, and that it should be perfectly stable in combination with other chemicals, such as potassium chlorate. The effect desired is a rather deep orange yellow. There is no objection to the use of dyes should these give the effect required and be procurable in large quantities at a reasonable price.

A suitable formula for a red smoke signal is also a desideratum. The effect required is a pronounced and positive shade of red. As in the case of the yellow smoke signal, chemicals composing it should be readily procurable and should be stable.

Problem No. 6. Rifle Grenade and Impact Grenade—An improved hand grenade is wanted with the following characteristics:

1. Rifle Grenade: (1) Simplicity of construction and operation; (2) light weight (under 20 oz.); (3) safety; (4) sureness of explosion; (5) long range (between hand grenade and trench mortar); (6) no damage to rifle from use; (7) should require no special ammunition; (8) adaptability for use as hand grenade as well as rifle grenade; (9) designed to secure maximum fragmentation and hold maximum amount of explosive; (10) should not require special tromblon or discharger; (11) detonators inserted separately.

2. Ideal Impact Grenade: (1) Must explode no matter what the angle of impact; (2) must explode on soft ground as readily as on hard ground; (3) safety; (4) simplicity of construction and operation; (5) fit easily in the hand; (6) light weight (not over 22 oz.); (7) be adaptable for use in grenade thrower with safety; (8) should permit rough handling; (9) weather-sound and flash-proof; (10) detonators inserted separately.

Problem No. 7. Improvement in Cable Braces for Airplanes—The present method of attaching the ends of cables to turnbuckles and anchorages is by bending the end of a cable around a protecting liner and wrapping the overlapping end with brass wire, which is afterward soldered. This is an unsatisfactory, wasteful and expensive method. If some very simple method of anchoring cable ends could be devised, it will greatly speed up the production of aircraft.

Electric Arc Welding*

BY ROBERT E. KINKEAD†

In presenting a paper to a body of engineers on the subject of electric welding, it seems advisable to treat the subject in general terms and to cover, so far as possible, the whole field, allowing points of particular interest to come up in the discussion to follow.

There are two general kinds of welding—that which requires heat and mechanical pressure and that which requires heat only. The first kind includes forge welding, electric butt and spot welding and electro-percussive welding. The second kind of welding includes the thermit welding process, the oxyacetylene and electric-arc processes. The two last-named processes are called autogenous welding. An autogenous weld is made by heating the metals to a liquid state and pouring them together into a homogeneous molten mass and allowing them to cool. The source of the heat required to melt the metal does not alter the principle of the operation, but does necessitate different methods of performing it. With few exceptions the same operations may be accomplished with either the oxyacetylene or the electric-arc process. The electric-arc has a higher temperature than the oxyacetylene flame and the great part of its heat is produced in an extremely localized area *within* the metal to be welded rather than external to it, as is the case in the oxyacetylene flame. The heat of the arc being produced in the metal is more efficiently

*Paper presented before the Cleveland Engineering Society.

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used, so that it is possible to do at least three times as much welding with a given amount of heat produced by the electric-arc as would be possible with the same amount of heat produced by the gas process. The approximate heat quantities involved in the welding arc are easily calculated from this formula:

$$H = \frac{E \times I}{1{,}000} \times T \times 3{,}413$$

H = Heat in British thermal units;
E = Average voltage across arc;
I = Average current in the arc circuit;
T = Time arc is in operation in hours.

The factor 3413 is the heat equivalent of 1 kw.-hr. energy in British thermal units.

The heat liberated by the oxyacetylene flame may be calculated, knowing that 1 cu.ft. of an oxyacetylene mixture gives about 1550 B.t.u. of heat.

The cost of producing a unit of heat for autogenous welding with the present prices of gas and electric power is about in a ratio of gas, 3; electric, 1. With an "effectiveness" factor of about 1 to 3 in the use of the two processes, it is evident that the cost of gas is in the neighborhood of nine times the cost of electric power doing the same work.

Up to the present time the electric-arc welding process has been used almost exclusively in the welding of steel. The very great localization of heat of the arc gives it a marked advantage over the oxyacetylene plant for welding on boiler plate and sheet metal. The difficulties arising from expansion and contraction with the attendant buckling of the plate and cracking of the weld encountered in the use of the gas processes are, to a certain extent, eliminated in the arc process owing to this localization of the heat.

Gray iron may be welded with the carbon-arc welding process, but the operation is somewhat more difficult than welding with the gas flame and perhaps requires more skill on the part of the operator.

The commercial applications of the electric-arc welding process are very interesting. By the use of the process it has been possible to accomplish certain things that were not possible before. It is often possible, by its use, to obtain in a few hours essentially the same results that a few years ago would have required ten times the labor and perhaps ten times the actual working time. The use of electric power for autogenous welding is another triumph for electricity.

One of the most interesting applications of the electric-arc welding process is in the locomotive shops and roundhouses of the country. This is an application that is growing in importance daily. The steam locomotive is merely a large number of pieces of steel bolted or riveted together. Each piece and the whole is subjected to the most severe stresses. Most of the parts are subjected to excessive wear, and the boiler is worked to the limit of its capacity under most unfavorable conditions. Under present war-time conditions of railroad traffic motive power is being kept on the road double the number of miles that was considered possible two years ago, before finally coming back to the locomotive shop. The electric-arc welding process is used to weld the flues into the back-flue-sheet of the boiler; to weld cracks and patches in the fire-box; to weld in new sections of the flue-sheet, door-sheet or side-sheets. Broken frames are welded in from six to ten hours without dismantling the engine. Worn links, guides, hangers, etc., are built up with new metal, remachined and put into service in a few hours' time. Worn flanges on the drive wheels are built up without dropping the wheels and the engine is put in service without turning the tire.

Industrial Lighting as a War Problem

On Nov. 12 a joint meeting of the Chicago sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers and the Western Society of Engineers was held in the rooms of the society last named. Prof. C. E. Clewell, of the University of Pennsylvania, was the speaker of the evening. As the basis of his address Professor Clewell used data which he had collected originally for the War Industries Board, to be used for the instruction of employment managers of war industries. The data dealt with the effect of proper natural and artificial lighting upon industrial production covering the fields of interior and protective lighting. Since the data will be published later in complete form, no attempt was made to give the figures in individual instances, the speaker preferring rather to outline the general character of the information available and to point out the principles and the trends involved. His address was illustrated with slides showing examples of both natural and artificial lighting.

In the discussion W. A. Durgin, of the Commonwealth Edison Co., spoke briefly on the high-intensity tests his company is conducting. Data from about 150 plants where the light had been increased from three to twenty-five times the original intensities showed increases in production ranging from 15 to 100 per cent., secured at a cost of about 5 per cent. of the payroll. The speaker maintained that it was conservative to state that a 15 per cent. increase in production could be secured through adequate lighting at an expense not to exceed 5 per cent. of the payroll. American engineers should realize that it is time to speed up to pay for the war, and better lighting is one way of doing it.

During the meeting the following officers were nominated for the mechanical and electrical sections of the Western Society of Engineers: Mechanical Section—F. J. Postal, chairman; B. A. Gayman, vice chairman; G. R. Brandon, A. L. Rice and J. L. Hecht, executive committee. Electrical Section—J. R. Cravath, chairman; Harold Almert, vice chairman.

The Fusibility of Coal Ash

"The Fusibility of Coal Ash and the Determination of the Softening Temperature" is the title of Bulletin 129, just issued by the Bureau of Mines, Department of the Interior.

In describing the purposes and scope of the investigations, the authors, A. C. Fieldner, Albert E. Hall, and A. L. Feild, say:

As a safeguard against excessive clinker troubles, specifications for the purchase of coal can be drawn to include the "softening" or "fusing" temperature of the ash. The value of such information has been recognized by the Bureau of Mines and has induced the bureau to investigate laboratory methods of determining the fusibility of coal ash, and the bearing of the results on clinker formation in fuel beds. The bureau realized that the fusibility of a mixture of oxides and silicates such as is comprised in coal ash varies according to the conditions under which tests are made, and that in the absence of any generally accepted method, no agreement is to be expected among tests made in different laboratories. Indeed L. S. Marks has recently called attention to differences as great as 390 deg. C. that were obtained with the same sample of ash by two different laboratories. Therefore if a fusion-temperature clause is to have any place in specifications for coal, a standard method of testing should be adopted in order to insure comparable results by different laboratories and to obtain the softening or fusing temperature of the ash under conditions similar to those of a fuel bed. After a consistent method has been devised for obtaining comparable results at different laboratories, there will remain the correlation of these results with those from the burning of coal in furnaces before the value of fusibility tests in coal specifications can finally be determined.

The present publication reviews the literature on the subject and gives in detail the effect of various oxidizing, reducing, and neutral atmospheres such as are found in various parts of the fuel bed on the softening temperature of ash when molded in the form of Seger cones. As a result of this study a practical method of determining fusibility has been developed whereby the ash is caused to soften and form slags in which the iron exists in approximately the same state of oxidation as the iron in fuel-bed clinkers.

Although it is believed that this method will indicate the probable clinkering characteristics of a coal better than any fusion tests heretofore described, the bureau does not recommend the general use of this method in coal specifications until it is justified by actual trial in furnace tests of different coals. As no fusibility test of a well-mixed sample of the average ash of a coal takes

into account the physical distribution of the impurities in the coal as burned, much additional investigation is needed to establish the exact relation of these laboratory fusibility tests to clinker formation. In order to correlate this proposed test of minimum softening temperature with clinker formation, the bureau is now making clinkering tests in a specially designed experimental furnace, in which different coals having ashes that differ in fusibility are burned under similar and known conditions of combustion. The results f this investigation will be published in a subsequent report. In the meantime it is hoped that other investigators will obtain similar correlation data.

Copies of this bulletin may be obtained free of charge by addressing the Director of the Bureau of Mines, Washington, D. C.

Personals

John H. Pardee, who was elected president of the American Electric Railway Association at the annual conference of that association held in New York, on Nov. 1, is president of the J. G. White Management Corporation, New York.

Engineering Affairs

Chicago Section A. S. M. E. will hold its first dinner meeting of the season at the Hotel La Salle on Dec. 13. D. L. Derron, of Winslow Brothers Co., Chicago, will speak on the manufacture of shells. It is expected that a motion-picture film will be used to illustrate the processes.

The American Society of Mechanical Engineers will hold its thirty-ninth annual meeting in the Engineering Societies Building, 29 West Thirty-ninth Street, New York City, Dec. 3-6. The following is the tentative program: On Tuesday evening there will be the presidential address, followed by a reception. On Wednesday morning the various committees will report, including that on Standardization of Flanges and Pipe Fittings. On Wednesday afternoon there will be simultaneous sessions as follows: Machine-shop Session: "Measurement of Thread Gages," by H. L. Van Keuren; "Standards for Large Taper Shanks and Sockets," by Luther D. Burlingame, and a probable report on the work of the British Engineering Standards Association, in connection with which the Bureau of Standards will give an exhibit of the measuring apparatus and methods of the Bureau in testing screw-thread gages. Joint Session on Refrigeration; the American Society of Refrigerating Engineers will hold a joint session with the A. S. M. E. The subjects will be: "Refrigerating Plant Efficiency," by Victor J. Azbe, and topical discussion on "Fuel Economy in Refrigerating plants." General Session: "Weights and Measures of Latin America," by Frederick A. Halsey, and papers on "Management," with particular reference to the U. S. Shipping Board. On Wednesday evening there will be a lecture on "The Achievements of Naval Engineering in the War," by Lieutenant-Commander William L. Cathcart, U. S. N. R. F. On Thursday morning: Keynote Session on the general subject of "Engineering of Man Power," which will be continued into the afternoon. Textile Session: "Industrial Power Problems," by W. F. Uhl; "Properties of Airplane Fabrics," by E. Dean Walen; "Daylight vs. Sunlight in Sawtooth-Roof Construction," by W. S. Brown; "Factory Stairs and Stairways," by G. L. H. Arnold. Gas Power Session: "The Cooling Losses in Combustion Engines as Affecting Design," by C. A. Norman; discussion of certain problems in regard to "Marine Diesel Oil Engines," by J. W. Anderson. On Friday morning there will be miscellaneous sessions: Power-Plant Session: "The Conservation of Heat Losses from Pipes and Boilers," by Glen D. Bagley; "Chemical and Physical Control of Boiler Operation and Application of Simple Formula for Estimating the Heat Loss Items," by E. A. Uehling. General Session: "The Relative Corrosion of Alloys," by R. B. Fehr; "The Relative Merits of Cast-Iron, Wrought-Iron and Steel Pipe for House Drainage Purposes," by William P. Gerhard; "The Design and Maintenance in Operation of Hydraulic Valves and Fittings for Use with Pressures from 1000-8000 lb. per sq.in.," by William W. Gaylord; "Mechanical Features of the Vertical-Lift Bridge," by Horatio P. Van Cleve.

Miscellaneous News

Crews for Merchant Marine Ships—One recruiting service that will not go out of business with the coming of peace is that of the United States Shipping Board. It will not only keep on doing business, but will increase its scope, according to Chairman Edward N. Hurley. Orders have gone out to the board's recruiting agents to rush enrollment of men for peace crews of merchant ships, especially firemen. "We shall want thousands of men for our peace fleets," said Mr. Hurley. "Our recruiting service, with twelve training ships, and bases at Boston, New York, Norfolk, New Orleans, San Francisco, Seattle and Cleveland, will keep right on preparing men for jobs under the American flag on merchant ships. This service is training at present 4000 apprentices a month, and we are planning to increase its output. The Shipping Board will continue until further notice to accept men between 18 and 35 inclusive for training. We want to build up an all-American personnel for the great merchant marine." Recruits for the peace fleet will be accepted at any one of 6800 drugstore enrolling stations maintained by the Shipping Board.

Positions for Technical Men—Apply to A. H. Krom, Director of Engineering, 29 S. La Salle St., Chicago, Ill. Refer to all positions by letter and numbers in parentheses accompanying them.

Mechanical Engineers (P.174-985-1): For field instruction in extension work; must possess practical experience and prefer men with technical education. Salary $2000 and expenses and one month's vacation with pay. Headquarters, Milwaukee.

Assistant Superintendent (P.170-955-1): Work in iron-works plant in Minnesota; must possess practical experience and be acquainted with modern manufacturing methods; engineering education absolutely essential. Salary depends on man.

Mechanical Engineer (P.167-839-6): Work in manufacturing plant in Cleveland, Ohio; a man capable of checking and estimating. $250 per month.

Plant Supervisors on Production (P.159-85-13): Work with large manufacturing company; Headquarters in Delaware.

Mechanical Engineer (P.150-833-1): Technical training, practical experience on machine tools and at the bench, for erecting engineer to install machinery in factory and ship yards. Will travel on Atlantic coast from Maine to Florida.

Production and Efficiency Engineers (P. 148-817-1): Work with Airplane Co. in Ohio.

Plant Superintendent (P.123-39-1): Work with a zinc rolling mill in Indiana. Salary, $3000 and up, according to ability.

Draftsmen (P.119-661-1): Mechanical and structural work about copper mining and reduction plant in Arizona, $200 per month. For Government contract work at Key West, Fla. (P.111-603-1) $180 per mo. Railroad work at St. Louis, Mo. (P-106-63-4) $125 to $150 per month. Airplane work in Detroit, Mich. (P.111-219-2). Mechanical work with coke and benzol plant, work in Ala. (P.88-307-3) $230 mo. Power plant draftsmen, with shipbuilding company in Fla. (P.182-355-6) $200 up. For bridge manufacturing company in Pittsburgh, Penn. (P.135-705-1). For machine manufacturing company in Seattle, Wash. (P.165-911-1).

Chemist and Assistant Chemist (P.126-657-2) Government work in Wis., $1500 to $3000. Chemical engineer with paper company in Maine (P.159-875-2). Chemical Engineer for work with soap company in New York (P. 166-929-2). Chemist in blast-furnace plant; must know silicon, sulphur, phos. and manganese in pig iron; work with iron company in Kentucky (P.134-701-1).

Business Items

The Ohio Brass Co., of Mansfield, Ohio, announces the removal of its New York office from 30 Church St., to 1781 Hudson Terminal Building, 50 Church St.

The Tilley-Gillette Co., 69 West Washington St., Chicago, will represent the Precision Instrument Co., of Detroit, covering the territory included in Illinois and Northern Indiana.

New Construction

PROPOSED WORK

N. Y., Buffalo—The Worthington Pump & Machinery Corp., Clinton and Roberts St., plans to construct a 1-story transformer house.

N. Y., New York—The Board of Education, 500 Park Ave., New York City, will install a steam heating system in the 5-story, 92 x 193 ft. school, which it will build on Crotona Ave. and 151st St. Total estimated cost, $450,000. C. B. J. Snyder, 500 Park Ave., New York City, arch.

N. Y., New York—The Hotel Construction Co., 18 East 41st St., has awarded the contract for the construction of a 28-story hotel on a site surrounded by Broadway, West 55th and 56th St. and 7th Ave. to Hoggson Brothers, 43rd St. and 5th Ave. A steam heating system wil be installed in same. Total estimated cost, $15,000,000.

N. J., Bloomfield—The International Arms & Fuse Co., Inc., Grove St., has had plans drawn for the construction of a 1-story, 38 x 40 ft. power house addition. Estimated cost, $7500.

N. J., Newark—Baker & Co., Inc., Railroad Ave., plans to construct a 34 x 36 ft. engine room. Estimated cost, $8400.

N. J., Oradell—The Board of Chosen Freeholders of Bergen County will install a steam heating system in the 4-story hospital which it plans to build here. Total estimated cost, $265,000.

Penn., Harriman—The Easton Gas & Electric Co. plans to construct an electric power plant at its local works to be operated by the Merchants Shipbuilding Corp.

Penn., Nanticoke—The Delaware, Lackawanna & Western R.R. is receiving bids for the construction of an addition, also remodeling its 1-story, 50 x 80 ft. boiler house. Estimated cost, $40,000. W. W. Ingils, Gen. Mgr.

Penn., Naticoke—The Liberty Throwing Co. plans to build a 1-story, 32 x 50 ft. boiler house on Church St. Estimated cost, $8000. Austin L. Reilly, Bennett Bldg., Wilkes-Barre, Arch.

Va., Riverton—The Shenandoah Valley Milling Co., 706 Munsey Bldg., Baltimore, Md., plans to build a 1-story power plant in connection with the flour mill it plans to build. Total estimated cost, $100,000. Alfred M. Quick, 706 Munsey Bldg., Baltimore, Md., Arch.

S. C., Paris Island—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to build extensions to heating system and power house here. Estimated cost, $97,000.

Ala., Birmingham — The Birmingham Railway, Light & Power Co., 2100 1st Ave., plans to improve its plant. C. F. Christian, Engr. Power Station.

Miss., Meridian—The city will install a steam-driven pumping unit having a capacity of 500,000 gal. Xavier A. Kramer, Magnolia, Engr.

Miss., Tutwiller—The city will soon vote on bond issue for the installation of an electric-light plant.

La., Alexander—W. Bradford, Engr., is interested in project to construct irrigation and navigation system, to include the erection of a hydro-electric plant. Will divert waters of Red River to Gulf.

Ky., Greenup—Citizens plan to rebuild the electric light plant recently destroyed by fire.

Ohio, Cleveland—The Aluminum Castings Co., Harvard Ave., has had plans drawn for the construction of a power house. J. H. Williams, c/o owner, Engr. Noted Nov. 19.

Ohio, Steubenville—The city plans to install 2 motors in the new filtration plant. Estimated cost, $1600.

Mich., Detroit—The Y. W. C. A. will install boilers and appurtenances for the steam heating system in the 2-story service building which it will build on East Grand Blvd. Total estimated cost, $100,000 Marcia Mead, 232 Hubbard Ave., Arch.

Mich., Ishpeming—The Cleveland Cliffs Co. plans to construct an electric power plant at its works here.

Mich., Port Huron—Loran C. Elliott, City Clerk, will soon award the contract for furnishing and installing 2 motor driven centrifugal pumps with equipment and 1 Venturi meter, at the waterworks.

Mich., Republic — The Cleveland Cliffs Co., Ishpeming, plans to construct an electric power plant at its works here.

Ill., East Chicago—Armour & Co., Union Stock Yards, Chicago, plans to build a power house. Estimated cost, $60,000. R. C. Clark, c/o owner, Arch.

Wis., Beloit — The Beloit Iron Works plans to build a concrete boiler shop and core room addition to its plant. Estimated cost, $20,000.

Minn., Ironton—The Cuyuna Range Power Co. plans to move its plant from Deerwood to Ironton and will install motors and lamps to furnish electricity to town of Motley.

S. D., Madison—The city plans to build an electric-light and water-works plant. Estimated cost, $100,000. M. N. Rae, City Auditor.

Tex., San Angelo—C. C. McBurnett plans to install and operate an electric-light and power plant in the St. Angelus Hotel Estimated cost, $12,000.

Col., Craig—R. M. Dutcher, Pierce, Neb., plans to construct and operate an electric light plant and system here.

Colo., Julesboro—The city plans to improve its electric light plant. Estimated cost, $25,000.

Wash., Spokane—The Washington Water Power Co. plans to build a new power plant. Estimated cost, $3,000,000. C. F. Uhden, Ch. Engr.

Que., Montreal—The City Commissioners plan to electrify half of the waterworks pumping station.

Ont., Amherstburg—The Town Council is in the market for new transformers and electrical equipment. Fred Park, Mayor.

Ont., Sault Ste. Marie—The Algoma Steel Corporation is in the market for a centrifugal pump, having a capacity of 1500 gal. per minute, water actually pumped at pressure of 500-lb. per square inch; direct connected to suitable motor for circuit 2200 volts, 3-phase, 25 cycle.

CONTRACTS AWARDED

N. H., Portsmouth—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing turbo-generators in the Navy Yard here, to the Allis-Chalmers Co., Southern Bldg., Washington, D. C. Estimated cost, $39,188.

Conn., Leesville—The Central Connecticut Power Co. will build a 1-story power house. Estimated cost, $26,000. Jenks & Ballow, 735 Grosvenor Bldg., Providence, R. I., Engrs.

N. J., Jersey City—The National Grocery Co., Montgomery St., has awarded the contract for installing a heating plant in their bakery building, to Diehl & Gross, 309 Grand St. Estimated cost, $13,600.

Penn., McKeesport—The Firth Sterling Steel Co., Demmler St., has awarded the contract for the construction of a pump house and coal handling plant, to Phiel & Miller, Wabash Bldg., Pittsburgh. Estimated cost, $200,000.

Penn., Milton—The Construction Division of the War Department, Washington, D. C., has awarded the contract for the construction of a power house to be operated by the Milton Manufacturing Co., to the Cleveland Construction Co., Citizens Bldg., Cleveland, Ohio. Estimated cost $100,000.

Penn., Philadelphia — The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing turbo-generators in the Navy Yard here, to the Westinghouse Electric and Manufacturing Co., Hibbs Bldg., Washington, D. C. Estimated cost, $49,999. Noted Sept. 10.

D. C., Bellevue—The United States Government has awarded the contract for erecting a central heating plant and 7 storehouses here, to the George F. Pawling Co., South Penn Sq., Philadelphia, Penn. Total estimated cost, $30,000.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing turbo-generators in Navy Yard here, to the Westinghouse Electric and Manufacturing Co., Hibbs Bldg., Washington, D. C. Estimated cost, $119,100. Noted Sept. 10.

Va., Newton (Norfolk P. O.)—The Manganese Steel Casting Co. has awarded the contract for the construction of a steel casting plant on the Eastern Branch of the Elizabeth River, to the General Contract Co., 409 Citizens Bank Bldg., Norfolk. Project includes the erection of a power house, furnace house, machine shop, etc. Total estimated cost, $300,000.

Va., Norfolk—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing electric lighting and power system in steel forage building here, to Harry Alexander, Inc., 20 West 34th St., New York City, N. Y. Estimated cost, $9700. Noted Nov. 12.

Va., Norfolk — The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing turbo-generators in the Navy Yard here, to the Westinghouse Electric and Manufacturing Co., Hibbs Bldg., Washington, D. C. Estimated cost, $49,999. Noted Sept. 10.

S. C., Charleston—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing turbo-generators in Navy Yard here, to the Westinghouse Electric and Manufacturing Co., Hibbs Bldg., Washington, D. C. Estimated cost, $41,123. Noted Sept. 10.

La., New Orleans—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing turbo-generators in the Navy Yard here, to the General Electric Co., Hibbs Bldg., Washington, D. C. Estimated cost, $34,400. Noted Sept. 10.

Mich., Detroit—The Board of Water Commissioners has awarded the contract for building and delivering f.o.b. cars at Detroit Water Works pumping station, 1 horizontal motor-driven centrifugal pumping unit, having a capacity of 70,000 gal. per minute and 1 with 45,000 gal. capacity per minute, to Allis-Chalmers Manufacturing Co., West Allis St., Milwaukee, Wis. Estimated cost, $53,000. Noted Nov. 12.

Iowa, Des Moines—The Douglas Co., 104th Ave. and 4th St., Cedar Rapids, has awarded the contract for the construction of a 2-story, 59 x 120 ft. pumping station, to the Leonard Construction Co., 332 Michigan Ave., Chicago, Ill. Estimated cost, $100,000.

Minn., St. Cloud—The city has awarded the contract for the Waterous motor propelled triple combination pumping engine, to the Waterous Engine Works Co., 80 East Fillmore Ave., St. Paul. Estimated cost, $2750.

Minn., Virginia—The city has awarded the contract for the construction of a 1-story, 30 x 40 ft. power house addition to the National Contracting Co., Alexander. Noted Nov. 12.

Minn., Worthington—W. H. Buchanan, City Clerk, has awarded the contract for the construction of an addition to the electric lighting plant, to the Lawrence Construction Co., Builders Exchange, Minneapolis. Estimated cost, $25,453. Noted Nov. 19.

Mo., Kansas City—The Kansas City Light & Power Co., 15th and Grand Ave., has awarded the contract for the construction of a 1-story, 50 x 57 ft. substation, to the E. L. Winn Construction Co., 105 Railway Exchange Bldg. Noted Nov. 5.

Cal., Mare Island (Vallejo P. O.)—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for installing turbo-generators in the Navy Yard here, to Allis-Chalmers Co., Southern Bldg., Washington, D. C. Estimated cost, $63,000. Noted Sept. 10.

Ont., Turbine—The International Nickel Co., Copper Cliff, has awarded the contract for power development here, to the Fraser Brace Co., 83 Craig St., W., Montreal, Que. Estimated cost, $2,000,000.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck.	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70		$3.25—3.40
Mine-run	2.35—2.50		3.00—3.15
Screenings	2.05—2.20		2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene,			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St Louis is $1.10.

other rates p. 95.